

PATENT COOPERATION TREATY

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

From the INTERNATIONAL BUREAU

To:

Assistant Commissioner for Patents
United States Patent and Trademark
Office
Box PCT
Washington, D.C. 20231
ETATS-UNIS D'AMERIQUE

in its capacity as elected Office

Date of mailing (day/month/year) 19 July 2000 (19.07.00)	
International application No. PCT/IL99/00572	Applicant's or agent's file reference 117024.0 SZ
International filing date (day/month/year) 29 October 1999 (29.10.99)	Priority date (day/month/year) 29 October 1998 (29.10.98)
Applicant RADOMSKY, Israel	

1. The designated Office is hereby notified of its election made:

☒ in the demand filed with the International Preliminary Examining Authority on:

29 May 2000 (29.05.00)

☐ in a notice effecting later election filed with the International Bureau on:2. The election ☒ was☐ was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland Facsimile No.: (41-22) 740.14.35	Authorized officer Manu Berrod Telephone No.: (41-22) 338.83.38
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INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference 117024.0 SZ	FOR FURTHER ACTION see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
International application No. PCT/IL 99/ 00572	International filing date (day/month/year) 29/10/1999	(Earliest) Priority Date (day/month/year) 29/10/1998
Applicant ELPAS ELECTRO-OPTIC SYSTEMS LTD. et al.		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 3 sheets.

☒ It is also accompanied by a copy of each prior art document cited in this report.

1. Basis of the report

- a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

☐ the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

- b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

☐ contained in the international application in written form.

☐ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority in written form.

☐ furnished subsequently to this Authority in computer readable form.

☐ the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

☐ the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. ☐ **Certain claims were found unsearchable** (See Box I).

3. ☐ **Unity of invention is lacking** (see Box II).

4. With regard to the **title**,

☒ the text is approved as submitted by the applicant.

☐ the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,

☒ the text is approved as submitted by the applicant.

☐ the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No.

☒ as suggested by the applicant.

☐ because the applicant failed to suggest a figure.

☐ because this figure better characterizes the invention.

5a _____

☐ None of the figures.

INTERNATIONAL SEARCH REPORT

International Application No

PC 99/00572

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 H04B10/10 H04L12/28

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 H04B H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 742 238 A (FOX CHRISTOPHER WAYNE) 21 April 1998 (1998-04-21) abstract column 1, line 9 - line 13 column 2, line 20 - line 28 column 3, line 37 - line 67 column 7, line 22 - line 28 column 7, line 35 - line 49 --- -/--	1-14

☒ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search

23 May 2000

Date of mailing of the international search report

31/05/2000

Name and mailing address of the ISA

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Authorized officer

Adkhis, F

INTERNATIONAL SEARCH REPORT

International Application No

PC 99/00572

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	<p>MARTIN B W: "WITCHIT. A FULLY SUPERVISED IDENTIFICATION, LOCATION AND TRACKING SYSTEM"</p> <p>PROCEEDINGS OF THE ANNUAL INTERNATIONAL CARNAHAN CONFERENCE ON SECURITY TECHNOLOGY,US,NEW YORK, IEEE, vol. CONF. 29, 1995, pages 306-310, XP000585871 ISBN: 0-7803-2628-8</p> <p>abstract</p> <p>page 308, left-hand column, line 1 - line 22</p> <p>page 309, left-hand column, line 1 -right-hand column, line 8</p> <p>-----</p>	1-14

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PO 99/00572

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5742238 A	21-04-1998	NONE	

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INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference 117024.0 SZ	FOR FURTHER ACTION See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)	
International application No. PCT/IL99/00572	International filing date (day/month/year) 29/10/1999	Priority date (day/month/year) 29/10/1998
International Patent Classification (IPC) or national classification and IPC H04B10/10		
Applicant ELPAS ELECTRO-OPTIC SYSTEMS LTD. et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.


2. This REPORT consists of a total of 8 sheets, including this cover sheet.

☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

These annexes consist of a total of 13 sheets.

3. This report contains indications relating to the following items:

- I ☒ Basis of the report
- II ☐ Priority
- III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- IV ☐ Lack of unity of invention
- V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- VI ☐ Certain documents cited
- VII ☐ Certain defects in the international application
- VIII ☐ Certain observations on the international application

Date of submission of the demand 29/05/2000	Date of completion of this report 08.02.2001
Name and mailing address of the international preliminary examining authority:  European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Katruff, M Telephone No. +49 89 2399 2440



INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/IL99/00572

I. Basis of the report

1. This report has been drawn on the basis of *(substitute sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments (Rules 70.16 and 70.17).):*

Description, pages:

1,2,5-10,15-21	as originally filed	
3,3a-3b,11-14	with telefax of	21/12/2000
4		
4a	with telefax of	01/02/2001

Claims, No.:

1-14	with telefax of	21/12/2000
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Drawings, sheets:

1/17-17/17	as originally filed
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2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is:

- ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/IL99/00572

4. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
- ☐ the claims, Nos.:
- ☐ the drawings, sheets:

5. ☒ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

see separate sheet

6. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-14
	No:	Claims	none
Inventive step (IS)	Yes:	Claims	5-10
	No:	Claims	1-4, 11-14
Industrial applicability (IA)	Yes:	Claims	1-14
	No:	Claims	none

2. Citations and explanations
see separate sheet

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT - SEPARATE SHEET**

International application No. PCT/IL99/00572

Re Item I

Basis of the report

1. **New claim 7** is based on the description on page 11, lines 12-22.

2. **Article 34(2) PCT**

According to the applicant, **new claim 1** shall be based on the original claims 1 and 7. However, no well defined basis could be found for the two passages of claim 1, on page 22, line 7-9 and lines 19-22 (...", thus allowing the reader... time frames thereof, and") .

Moreover, a direct combination of original claims 1 and 7 would establish a new, possibly unsearched combination of features. As original claim 7 is dependent on original claim 5 (but not on claim 1), the subject-matter of this claim would also have to be included in new claim 1.

Therefore, for the purpose of the IPER, claim 1 has been read as if the two above cited passages were not present (i.e. the originally filed version of claim 1).

Re Item V

Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Reference is made to the following documents:

D1: DE-C-33 04 451 (1984-10-19)

D2: US-A-5 742 238 (FOX CHRISTOPHER WAYNE) 21 April 1998

The document D1 was not cited in the international search report. A copy of the document was appended to the Written Opinion.

2. **Article 33(3) PCT**

a) Document D1, which is considered to represent the most relevant state of the art, discloses (the references in parentheses applying to this document):

a method for effecting bi-directional IR data communication (abstract, lines 1-6) between a [...] reader (abstract, "stationäre Hauptstation (H)") and a plurality M of portable objects each having associated therewith a respective

object transceiver (abstract, "mobile Unterstationen (U1, U2,...)") which [...] has embedded therein a respective object ID (abstract, line 13, "spezifische Codenummer (CN)") uniquely identifying the object, the method comprising the steps of:

[...] each reader transmitting a Reader Control Message (abstract, lines 9-14, "Datenblock (DB1)") including a header; [...] followed by up to K object IDs, with $K < M$, each in respect of one of the object transceivers a respective command (see fig. 4, e.g. DB3, DB5, containing CNs) for controlling the respective object transceiver (e.g. to block the "Unterstation" after successfully having received its message, see abstract lines 14-19),
allocating up to K data slots (fig. 4, Zeitbereiche ZB1, ..., ZB8, and column 4, lines 40-43) each for allowing communication of a data message (abstract and fig.4, "Datenblock DB1") between the respective reader and one of the object transceivers, and
allowing each of the M object transceivers to randomly select (abstract, lines 9-14, "innerhalb eines zufällig ausgewählten Zeitbereichs") of one of R allocation slots for transmitting limited capacity data (abstract, line 12, "Informationsdaten") therein to the respective reader

from which the subject-matter of **claim** only differs in that:

- (i) the respective object transceiver **is initially dormant**
- (ii) each reader transmitting to an object transceiver a preamble containing a **carrier signal for awaking the object transceiver** from its initially dormant state
- (iii) there is a **plurality N of readers**
- (iv) the Reader Control Message containing a respective **reader ID** so as to allow the reader to be addressed when required

b) A first problem to be solved by the present invention may therefore be regarded as how to realize a low power consuming method of tracking objects.

c) A second problem to be solved by the present invention may therefore be regarded as how to realize a method of tracking objects with extended coverage.

d) The solution proposed in **claim 1** of the present application cannot be considered as involving an inventive step (Article 33(3) PCT) for the following reasons:

(1) Document D2 discloses (see abstract and fig. 1) a system for communication between a central controller and items in a factory using IR light. The system contains a plurality of readers (D2, fig.1, 9) and a plurality of micro terminals (D2, fig. 1, 12).

(2) Features (i) and (ii) are described in document D2 as providing the same advantages as in the present application (i.e. to control the object transceivers to increase battery life; see D2, column 7, lines 50-54 and column 8, lines 47-56). The skilled person would therefore regard it as a normal option to include these features in the method described in document D1 in order to solve the first problem posed.

(3) Further, the use of more than one reader station (feature (iii)) is already disclosed by D2 (see, fig. 1, 9). Feature (iv) is due to the fact, that a plurality of readers is employed and an object transceiver may easily be placed at a site where it could receive IR-signals from more than one reader at the same time. Therefore, the use of reader-IDs in the RCM-messages has to be regarded as a normal design alternative, well-known to a person skilled in the art.

(4) In view of the paragraphs (1)-(3) above, the skilled person would regard it a normal design procedure to include the features (i) - (iv) into the method disclosed by D1 to obtain the advantage of the desired solution given by **claim 1**. Thus, the subject-matter of **claim 1** does not involve an inventive step and does not satisfy the criterion set forth in Article 33(3) PCT.

e) The same objection holds in an analogous way also for **claims 12-14**.

The object transceiver, the reader and the system defined in independent **claims 12-14** can also not be regarded as involving an inventive step with respect to a combination of documents D1 and D2, because **claims 12-14** do not contain additional explicit features and do not contain any additional implicit features, even

when referring to an object transceiver or the reader of **claim 1**, or a system containing both.

f) Dependent **claims 2-4 and 11** do not contain any features which, in combination with the features of any of claims 1-4 to which they refer, meet the requirements of the PCT in respect of inventive step, the reasons being as follows:

- (i) the subject-matter of **claims 2-4 and 11** is already disclosed by document D1 (see column 4, lines 16-18, HDLC-Protocol for claims 2-4; see abstract for claim 11)

3. Article 33(2) and (3) PCT

a) The subject-matter of **claims 5-10** of the present application is novel and involves an inventive step (Article 33(2) and (3) PCT) for the following reasons:

The subject-matter of **claims 5 and 10** (which are dependent on claim 1) essentially differs from the prior art of D1 in that:

- (i) step (d): any object transceiver receiving the location ID of a proximate reader; compares the location ID with a current location ID stored in the object transceiver corresponding to the object's current location, (claim 5);
- (ii) step (e): if the location ID received in step (d) is not the same as the current location ID in the object transceiver; the object transceiver randomly selects one of the R allocation slot for transmitting its respective object ID to the reader associated with its current location and stores the respective location ID of the reader (claim 5);
- (iii) each of the object transceivers randomly selecting additional object transceiver data slots, as required, to completely transmit said object data stream (claim 10)

b) The problem to be solved by the present invention may therefore be regarded as how to provide an improved method of keeping track of objects by means of IR transceivers.

c) The main advantage of the solution proposed in **claims 5 and 10** can be seen in that the method allows for low energy consumption (features (i) and (ii))

portable tags that may be attached to movable objects. The portable object transceivers don't have to transmit constantly their own ID but only in case they are interrogated by a reader or when they receive interrogations from a (second) reader with another location ID.

The advantage of feature (iii) is that it allows for a more cost effective object tracking system by enabling communication of a greater number of object transceivers with a single reader. In case the 4 data slots (DSM1-4) are not sufficient, allocated slots can be used instead.

d) D1 describes a method for the bi-directional transmission of information between a stationary main station (H) and several mobile secondary stations (U1, U2,...) using electromagnetic waves. The main station communicates with the mobile station via HDLC protocol data block transmission. No indication regarding the features (i)-(iii) is given.

D2 refers to a system for communication between a central controller and items in a factory using infrared light. The system uses micro terminals attached to workpieces and a central control system with IR transceivers. The micro terminals have 4 modes of operation to extend the battery life, however, no indication regarding the solution of the application is given.

e) **Claims 6-9** are dependent on **claim 5** and as such also meet the requirements of the PCT with respect to novelty and inventive step.

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This having been said, the periodic transmission by each portable tag of its corresponding ID also results in a great amount of redundant data being transmitted. For example, if each tag transmits its ID once every 10 minutes and a file remains in a particular room for a whole week, this would result in the portable tag transmitting its ID to the same interrogation device over 1000 times per week, when only a single transmission would suffice. This, clearly, is an extravagant waste both of energy and of data transmission with the associated time overhead.

Yet a further consideration must be borne in mind when data is transmitted using optical transceivers. For example, infrared (IR) transceivers are particularly suited for the kind of task in question and require an optically transparent path unencumbered by obstacles for effective data transmission. On the other hand, if even inadvertently optical transparency is maintained between one room and an adjacent room, then there exists the risk that a file located in one room might transmit its ID to the interrogation device associated with a different, adjacent room. Such optical transparency might, for example, be the result of a dividing door between the two rooms being ajar; or owing to a window between the two rooms permitting infrared transmission therethrough.

Furthermore, in order to render such a communication system as efficient as possible, it is desirable to permit more than one portable tag to communicate with the interrogation device simultaneously. This desideratum clashes with the requirement to avoid collisions which, with I.R. transceivers is particularly onerous on account of the fact that it is difficult to detect collisions owing to the half-duplex communications protocol inherent in I.R. transmission.

SUMMARY OF THE INVENTION

It is thus an object of the present invention to provide a method for keeping track of objects in which the drawbacks described above are significantly reduced or eliminated.

5 It is a particular object of the present invention to provide an improved communications protocol suitable for use with IR transceivers allowing near simultaneous two-way communication between an interrogation device and a plurality of IR transceivers.

10 In accordance with a first aspect of the invention there is provided a method for effecting bi-directional IR data communication between a plurality N of readers and a plurality M of portable objects each having associated therewith a respective object transceiver which is initially dormant and has embedded therein a respective object ID uniquely identifying the object, the method comprising the steps of:

15 each reader transmitting to an object transceiver a preamble containing a carrier signal for awaking the object transceiver from its initially dormant state,

each reader transmitting a Reader Control Message (RCM) including a header; a respective reader ID so as to allow the reader to be addressed when required followed by up to K object IDs ($K < M$) each in respect of one of said
20 object transceivers and each being followed by a respective command for controlling the respective object transceiver,

allocating up to K data slots each for allowing communication of a data message between the respective reader one of said object transceivers, and

allowing each of the M object transceivers to randomly select of one of
25 R allocation slots for transmitting limited capacity data therein to the respective reader.

A particular application of such a communications protocol relates to a method for keeping track of objects each having a respective unique identity and subject to movement between different locations, wherein:

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mounted For ease of explanation, the respective location IDs for each of the location transceivers 21, 22 and 23 will be denoted by the corresponding room number #11, #12 and #13. Each of the readers 21 to 23 periodically communicates its location ID to the badges in its area of reception so that the location of each badge may be stored therein. In order to prevent the risk of data collisions between the location transceivers 21 to 23, the communications protocol employs a data frame configuration wherein four different data slots DS1, DS2, DS3 and DS4 are allocated one to each of four different readers. Thus, each of the location transceivers 21 to 23 can transmit data only in its own data slot thus avoiding the risk of data collisions between two or more respective location transceivers in mutual line of sight with the same badge.

Each of the badges 25 and 26 receives an IR data string transmitted by the location transceiver 22 and, possibly, also by the location transceivers 21 and 23 if the adjoining door between adjacent rooms 11 and 12 or between 12 and 13 is open. However, because the distance between the location transceiver 21 in an adjacent room and the badge 25 is greater than that between the badge 25 and the location transceiver 22 in the same room 12 as the badge 25, the intensity of the data received from the adjoining location transceiver 21 will be reduced compared to that received by the correct location transceiver 22. This difference in signal intensity may be used in order to reject a weak signal emanating from a location transceiver in an adjoining room and thus containing the location ID of an incorrect location.

When one of the badges 25 or 26 receives the location ID #12 associated with the location transceiver 22, it compares the received location ID with the current location ID stored within its internal memory. If these are identical, this means that the ID associated with the location transceiver 22 corresponds to the current location ID within the memory of the badge and that consequently the badge has not moved since it was previously updated. In this case, unless the badges 25 or 26 need, for some reason, to transmit data other

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than their respective ID, their respective IR transceivers may remain silent. By such means, battery consumption may be reduced to an absolute minimum.

If, on the other hand, the location ID (#12) transmitted by the location transceiver 22 is different to that stored in the badge memory, this implies that the badge transceiver was moved into the room 12 since it was previously read. In this case, the location ID (#12) associated with the current location, i.e. the room 12, is now stored in the badge memory and the cycle is repeated.

Thus, referring now to Fig. 4, there is shown a typical frame configuration for allowing two-way wireless IR time division multiple access (TDMA) transmission between the reader and the badge. Each Reader Control Message (RCM) includes a header, a reader ID and a cellular slot ID so as to allow a particular reader to be addressed when required. The RCM further includes a badge ID in respect of four different badges which may be addressed at a corresponding one of four data slots in the frame so as to provide each badge with a command whose encoded data is transmitted at the corresponding slot. Finally, each RCM includes a CRC checksum which allows the integrity of the data received by the badge to be checked.

Following each RCM, are the four data slots depicted DSM1, DSM2, DSM3, and DSM4, respectively, within each of which a Data Slot Message (DSM) may be transmitted. Each DSM includes a header and a reader ID. The data slot may be used to transmit a long data message having between 16 to 64 bytes included within the DSM slot followed by a validation check and a CRC checksum byte. If, on the other hand, the data which is to be transmitted to a particular badge corresponds to a short data message, this is provided in the form of an Allocation Slot Message (ASM) which is transmitted in one of sixteen slots following the fourth data slot (DSM4). Each ASM comprises a header and a message type followed by a short data message of up to 16 bytes. Thereafter follows the badge ID followed by a CRC.

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Thus, each data cycle commences with a synchronization signal after which start synchronization signals are allocated in respect of each of the four data slots relating to the corresponding rooms 11 to 14. The four data slots may be needed (according to the four-color map theorem) in order to avoid having two areas whose respective readers attempt to transmit during the same data slot and thus avoid data collisions. It will be appreciated that if the topography shown in Fig. 1 is extended to include additional rooms, then those additional rooms may likewise be allocated data slots within the same overall cycle without in any way conflicting with the three location transceivers 21 to 23 shown in Fig. 1. For example, if there were an additional room adjacent to the room 12 but remote from the room 13, then providing such a room were allocated a different data slot to the two rooms 12 and 13, there would be no danger of collision between the data transmitted by the respective location transceivers in each of the three adjacent rooms. For such a topography, it may be shown that a minimum of four discrete data slots is sufficient to prevent data collisions. It will be appreciated from the foregoing that the invention allows communication between several readers and badges within a single data stream.

The manner in which the data slots are allocated so as to avoid data collisions may be pre-determined either by a professional installation expert with a software interface and an exact map of the area 10; or, it may be determined automatically, on a trial-and-error basis, by the location transceivers themselves by means of listening to each other's transmissions and proceeding with the definition in a neural/serial manner.

If a message must be addressed to the badge, or received thereby, within the area covered by the specific location transceiver, each RCM may contain commands and corresponding IDs in respect of up to five different badges. The commands control the use of the rest of the frame which, as shown, is divided into four data slots. An additional time is allocated at the end of the frame for badge allocation slots.

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Collision avoidance between the different location transceivers is achieved as explained above by allocating discrete data slots so that adjacent location transceivers may transmit only in their own respective data slots. Collision of data transmitted by different badges within a given area is achieved as follows. The badges do not transmit asynchronously. Instead, the location transceiver transmits the RCM and this defines the start of each frame. In each frame there are four data slots and sixteen allocation slots. If there is a message to be transmitted from the location transceiver to the badge, then the RCM transmitted to the badge includes command data for instructing the badge to receive the message in an allocated data slot. Longer messages may use more than one slot per frame (if preferred) or, alternatively, more slots in multiple frames.

A badge which needs to transmit its ID to a location transceiver, randomly selects one of the sixteen allocation slots for transmitting its ID therein. Thus, the probability of collision is reduced by 1:16 and in following frames 1: 16^2 etc. If the badge needs to transmit to the location transceiver a longer message including, for example, data other than the object's ID, then it initially transmits a message of type "allocation" and in the following frame it will then be instructed by the location transceiver to transmit its message in a specific data slot.

Fig. 5a shows respective data structures 70 and 71 for the reader and the badge during the nth frame as well as respective data structures 72 and 73 for the reader and the badge during a subsequent (n+1)th frame for data transmission of a long message from the reader to the badge. For the nth frame the reader transmits a RCM which is received by the badge to which it is addressed, whereby it is decoded and an acknowledgement is transmitted by the badge to the reader during a randomly allocated slot. During the next frame, the reader informs the addressed badge during which data slot message information will be transmitted. Thus, as shown in the data structures 72 and 73, message

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CLAIMS:

1. A method for effecting bi-directional IR data communication between a plurality N of readers (21, 22, 23) and a plurality M of portable objects each having associated therewith a respective object transceiver (24, 25, 26, 27) which is initially dormant and has embedded therein a respective object ID uniquely identifying the object, the method comprising the steps of:

each reader transmitting to an object transceiver a preamble containing a carrier signal for awaking the object transceiver from its initially dormant state,

each reader transmitting a Reader Control Message (RCM) including a header; a respective reader ID so as to allow the reader to be addressed when required followed by up to K object IDs ($K < M$) each in respect of one of said object transceivers and each being followed by a respective command for controlling the respective object transceiver,

allocating up to K data slots each for allowing communication of a data message between the respective reader one of said object transceivers, and

allowing each of the M object transceivers to randomly select of one of R allocation slots for transmitting limited capacity data therein to the respective reader.

2. The method according to Claim 1, wherein the data message includes a header and a reader ID of the respective reader followed by long message data having up to a predetermined number of bytes for transmission within the data slot.

3. The method according to Claim 1 or 2, wherein said limited capacity data comprises a header and a message type followed by a short message of up to a predetermined number of bytes data.

4. The method according to Claim 1 or 2, wherein said limited capacity data is an acknowledge signal.

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5. The method according to any one of Claims 1 to 4 for keeping track of up to M objects each having a respective unique identity and subject to movement between different locations, wherein:

- 5 (a) in each different location there is provided a respective one of said readers (21, 22, 23) each having associated therewith a location ID uniquely identifying the respective location,
 - (b) with each of the objects there is associated a respective one of the object transceiver (24, 25, 26, 27) having embedded therein a respective object ID uniquely identifying the object,
 - 10 (c) each of said location transceivers periodically transmits its location ID for receipt by any object transceiver within a boundary associated with said location,
 - (d) any object transceiver receiving the location ID of a proximate reader; compares said location ID with a current location ID stored
15 in the object transceiver corresponding to the object's current location,
 - (e) if the location ID received in (d) is not the same as the current location ID in the object transceiver; the object transceiver randomly selects one of said R allocation slot for transmitting its
20 respective object ID to the reader associated with its current location and stores the respective location ID of said reader, and
 - (f) the reader stores the respective object ID of each object associated therewith.
6. The method according to Claim 5, further including the step of:
- 25 (g) all of the readers transmitting the respective object IDs of all objects associated therewith to a central tracking receiver (28) for maintaining a record of all location IDs and associated object IDs.

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7. The method according to Claim 5 to 6, wherein a signal transmitted by a reader is able to travel beyond the boundary associated with the reader and step (d) includes the further step of:

5 (dl) allocating to potentially conflicting readers discrete data slots for transmitting their respective location IDs so that no more than one location ID can be received at any given time by an object transceiver.

8. The method according to Claim 7, wherein each of the locations is a room, the boundary is a wall separating the room from an adjacent room and four discrete data slots are allocated each in respect of one of up to four adjacent rooms so that the respective reader in each of the adjacent rooms
10 transmits during its data slot only.

9. The method according to any one of Claims 5 to 8, wherein if the location ID received by an object transceiver is the same as the current location ID stored therein, the object transceiver maintains silence so as to minimize
15 energy consumption.

10. The method according to any one of Claims 1 to 9, wherein the object transceivers are adapted to transmit an object data stream containing the respective object ID and an additional message, there being further included the step of:

20 each of the object transceivers randomly selecting additional object transceiver data slots, as required, to completely transmit said object data stream.

11. The method according to any one of the preceding Claims, wherein the object transceivers and readers are IR transceivers.

25 12. An object transceiver (24, 25, 26, 27) which is programmed to carry out the method according to any one of Claims 1 to 11.

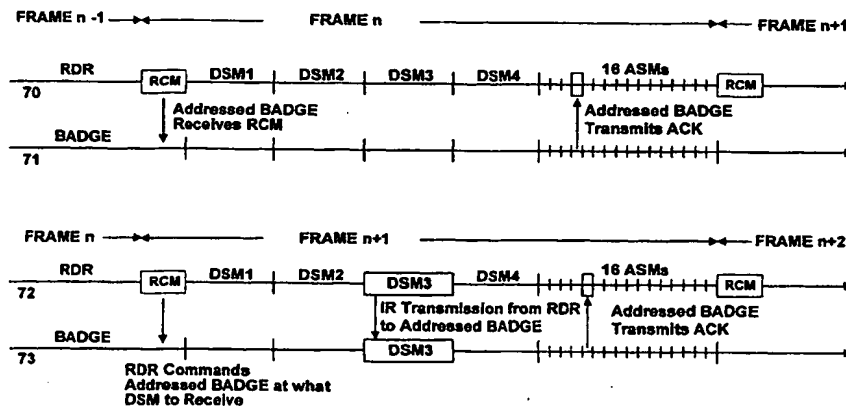
13. A reader (21, 22, 23) which is programmed to carry out the method according to any one of Claims 1 to 11.

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14. A system (10) comprising at least one reader (21, 22, 23) and at least one object transceiver (24, 25, 26, 27) which are programmed to carry out the method according to any one of Claims 1 to 11.

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(54) Title: SYSTEM AND METHOD FOR INFRARED COMMUNICATION



RDR to BADGE Long Message Transmission Protocol

(57) Abstract

A method and system for effecting bi-directional IR data communication between a plurality N of readers (21, 22, 23) and a plurality M of portable objects each having associated therewith a respective object transceiver (24, 25, 26, 27) which is initially dormant and has embedded therein a respective object ID uniquely identifying the object. Each reader transmits to an object transceiver a preamble containing the object ID for awaking the object transceiver from its initially dormant state, and a Reader Control Message (RCM) including a header; a respective reader ID so as to allow the reader to be addressed when required followed by up to K object IDs ($K < M$) each in respect of one of the object transceivers and each being followed by a respective command for controlling the respective object transceiver. Up to K data slots are allocated each for allowing communication of a data message between the respective reader and one of the object transceivers, and each of the M object transceivers may randomly select of one of R allocation slots for transmitting limited capacity data therein to the respective reader.

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System and method for infrared communication

FIELD OF THE INVENTION

This invention relates to a method for keeping track of objects and, in particular, to such a method for use with low consumption portable tags that may be affixed to movable objects so as to keep track of their geographic
5 location.

BACKGROUND OF THE INVENTION

There are many situations in which it is required to keep track of movable objects so as automatically to follow their movement. For example, in an office environment wherein files may be worked on by different members of
10 staff and are thus subjected to movement from one room to another, it is frequently necessary to keep track of their movement so that, for example, when incoming mail arrives in respect of a particular file, the file can immediately be located in an expeditious manner. One way in which this can be done is to affix to each file a portable tag which contains a memory for storing a
15 unique identity which may be read by a suitable interrogation device located, for example, at the entry to a room so that whenever the file moves into a new room, its identity is automatically determined for onward transmission to a central tracking computer which keeps a record of each file identification and its corresponding location.

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Such an approach is acceptable when objects bearing a respective portable tag are apt to move from one location to another discretely. However, this is frequently not the case. For example, in the case of the office environment as discussed above, if a member of staff ordered several files which were brought simultaneously, then, unless each file were to be separated from the stack so as to be capable of being individually read by the interrogation device, the interrogation device would be incapable of reading all the portable tags simultaneously. On the other hand, to separate the files on entry into a new location is clearly cumbersome.

One way in which such a major drawback can be overcome is to allow the portable tag periodically to transmit its ID to the interrogation device in order that the file ID can be associated with the location of the interrogation device and then routed to the central tracking computer. This clearly overcomes the disadvantage of attempting to read many portable tags simultaneously; but imposes the price that each portable tag must constantly transmit its ID to the interrogation device. This is undesirable for several reasons. First, still to consider the office environment by way of example, if there be a large number of files in a particular room, and each file has a portable tag which transmits periodically its ID to an interrogation device associated with that room, then the volume of data which must be transmitted can be quite significant. Secondly, this, in turn, increases the risk of data collision between the IDs transmitted by different portable tags and imposes additional overheads in preventing and/or managing data collisions. Thirdly, by their very nature, the portable tags are miniature devices that are energized by a small internal power source such as a small battery. The more data which is transmitted by each portable tag, the greater is the energy consumption and the more often the battery must be replaced. This is both inconvenient and potentially very expensive when large numbers of portable tags are envisaged.

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This having been said, the periodic transmission by each portable tag of its corresponding ID also results in a great amount of redundant data being transmitted. For example, if each tag transmits its ID once every 10 minutes and a file remains in a particular room for a whole week, this would result in
5 the portable tag transmitting its ID to the same interrogation device over 1000 times per week, when only a single transmission would suffice. This, clearly, is an extravagant waste both of energy and of data transmission with the associated time overhead.

Yet a further consideration must be borne in mind when data is
10 transmitted using optical transceivers. For example, infrared (IR) transceivers are particularly suited for the kind of task in question and require an optically transparent path unencumbered by obstacles for effective data transmission. On the other hand, if even inadvertently optical transparency is maintained between one room and an adjacent room, then there exists the risk that a file located in
15 one room might transmit its ID to the interrogation device associated with a different, adjacent room. Such optical transparency might, for example, be the result of a dividing door between the two rooms being ajar; or owing to a window between the two rooms permitting infrared transmission therethrough.

Furthermore, in order to render such a communication system as
20 efficient as possible, it is desirable to permit more than one portable tag to communicate with the interrogation device simultaneously. This desideratum clashes with the requirement to avoid collisions which, with I.R. transceivers is particularly onerous on account of the fact that it is difficult to detect collisions owing to the half-duplex communications protocol inherent in I.R.
25 transmission.

SUMMARY OF THE INVENTION

It is thus an object of the present invention to provide a method for keeping track of objects in which the drawbacks described above are significantly reduced or eliminated.

- 5 It is a particular object of the present invention to provide an improved communications protocol suitable for use with IR transceivers allowing near simultaneous two-way communication between an interrogation device and a plurality of IR transceivers.

10 In accordance with a first aspect of the invention there is provided a method for effecting bi-directional IR data communication between a plurality N of readers and a plurality M of portable objects each having associated therewith a respective object transceiver which is initially dormant and has embedded therein a respective object ID uniquely identifying the object, the method comprising the steps of:

- 15 each reader transmitting to an object transceiver a preamble containing a carrier signal for awaking the object transceiver from its initially dormant state,
each reader transmitting a Reader Control Message (RCM) including a header; a respective reader ID so as to allow the reader to be addressed when required followed by up to K object IDs ($K < M$) each in respect of one of said
20 object transceivers and each being followed by a respective command for controlling the respective object transceiver,

allocating up to K data slots each for allowing communication of a data message between the respective reader one of said object transceivers, and

- allowing each of the M object transceivers to randomly select of one of
25 R allocation slots for transmitting limited capacity data therein to the respective reader.

A particular application of such a communications protocol relates to a method for keeping track of objects each having a respective unique identity and subject to movement between different locations, wherein:

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- (a) in each different location there is provided a respective one of said readers each having associated therewith a location ID uniquely identifying the respective location,
- (b) with each of the objects there is associated a respective one of the object transceiver having embedded therein a respective object ID uniquely identifying the object,
- (c) each of said location transceivers periodically transmits its location ID for receipt by any object transceiver within a boundary associated with said location,
- (d) any object transceiver receiving the location ID of a proximate reader; compares said location ID with a current location ID stored in the object transceiver corresponding to the object's current location,
- (e) if the location ID received in (d) is not the same as the current location ID in the object transceiver; the object transceiver randomly selects one of said R allocation slot for transmitting its respective object ID to the reader associated with its current location and stores the respective location ID of said reader, and
- (f) the reader stores the respective object ID of each object associated therewith.

When it is sufficient for an object transceiver to transmit only its ID to the nearest location transceiver when the location ID associated therewith is different to the current location ID stored in the object transceiver, and no other information must be transmitted thereby, then unless the object moves from one location to another it can remain permanently shut down. This results in lower energy consumption and very significantly increases battery lifetime. On the other hand, the energy consumption associated with the location transceivers is less significant because they are fixed and may therefore be permanently connected to a conventional mains electricity supply.

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In order to prevent data collisions between adjacent location transceivers, a geographic area may be split into corresponding cells each representing a discrete geographical area such as, for example, a separate room each of which is allocated a separate time slice for transmitting therein its corresponding location ID. Likewise, in order to reduce the risk of data collision between different object transceivers, a plurality of separate data slots may be provided within each frame of data and each of the object transceivers may select one of the plurality of data slots randomly. Thus, providing that the ratio of the number of available data slots to the number of object transceivers which need to transmit at any given time is sufficiently high, the risk of two or more object transceivers attempting to transmit within the same data slot may be sufficiently reduced. Obviously, conventional data collision techniques requiring re-allocation of data slots and re-transmission of data may be employed in the event that, notwithstanding efforts to the contrary, two different object IDs are transmitted simultaneously.

BRIEF DESCRIPTION OF THE DRAWINGS

In order to understand the invention and to see how the same may be carried out in practice, a preferred example of the communications protocol will now be described with reference to a portable identity badge, by way of non-limiting example only, with reference to the accompanying drawings, in which:

Fig. 1 is plan view showing pictorially a geographical area split into adjacent rooms each containing a reader and one or more portable badges for carrying out the method according to the invention;

Fig. 2 is a block diagram showing functionally a portable badge transceiver for employing the method of the invention;

Fig. 3 is a block diagram showing functionally an IR receiver for use in the readers and badges illustrated in Fig. 1;

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Fig. 4 shows pictorially a message frame configuration according to a preferred communications protocol for use with the transceiver;

Figs. 5a to 5d show further details of long and short message communications protocols employed by the reader and badge;

5 **Figs. 6a and 6b** show details of the modulation scheme and reader transmission protocol;

Figs. 7a to 7e are timing diagrams showing successive frames of data of a long message transmitted by the Reader to the Badge;

10 **Figs. 8a to 8c** are timing diagrams of a data decoding circuit used in the IR receiver of the Badge;

Fig. 9a is a flow diagram showing details of a communications protocol for use by the reader during transmission of a long message from the reader to the badge;

15 **Fig. 9b** is a flow diagram showing details of a communications protocol for use by the badge during transmission of a long message from the reader to the badge;

Fig. 10a is a flow diagram showing details of a communications protocol for use by the reader during transmission of a long message from the badge to the reader;

20 **Fig. 10b** is a flow diagram showing details of a communications protocol for use by the badge during transmission of a long message from the badge to the reader;

25 **Fig. 11a** is a flow diagram showing details of a communications protocol for use by the reader during transmission of a short message from the badge to the reader; and

Fig. 11b is a flow diagram showing details of a communications protocol for use by the badge during transmission of a short message from the badge to the reader.

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DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

Fig. 1 shows in plan view a pictorial representation of a geographical area depicted generally as 10 comprising three separate and mutually adjacent rooms 11, 12, and 13. In each of the three rooms 11 to 13 there is mounted on the ceiling a corresponding reader 21, 22 and 23 constituting a location transceiver which allows transmission and reception of data using IR transmission. If a door (not shown) between the two rooms 11 and 12 be ajar, then an IR signal transmitted by the reader 21 so as to read all objects within the room 11 can pass through the open door into the adjacent room 12 and thus, incorrectly, read the objects therein. Likewise, the reader 22 can incorrectly read objects within the room 11 if the door between the two rooms is open. Finally, for the sake of description, there are shown objects having associated therewith a respective object transceiver 24, 25, 26 and 27 each constituted by a portable badge which can transmit data to a nearby reader as well as receiving data therefrom. The readers 21, 22 and 23 are connected via a communications network to a server 28 constituting a central tracking receiver.

Fig. 2 shows a block diagram of a badge depicted generally as 30 and including an IR photodiode 31 connected to an IR receiver 32 for receiving an IR signal from one of the ceiling-mounted readers 21, 22 and 23 shown in Fig. 1. An array of LEDs 33 is connected to an IR transmitter 34 for transmitting an IR signal to one of the readers 21, 22 and 23. A micro-controller 35 is coupled to both the IR receiver 32 and the IR transmitter 34 and operates in accordance with a stored instruction set defining communications protocols allowing both long and short messages to be communicated between the badge and reader. The various communications protocols are described in detail below with particular reference to Figs. 9a to 11b of the drawings. Coupled to the micro-controller 35 is a buzzer 36 and a display 37 as well as an array of manual switches S1, S2, S3 and S4 allowing pre-programmed functions to be manually selected in accordance with the instruction set stored in the micro-

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controller 35. The badge circuitry is powered by a battery 38 connected to the micro-controller 35, the IR receiver 32 and the IR transmitter 34 via a power supply controller 39. The buzzer 36 and the display 37, in addition to the manual switches S1, S2, S3 and S4, allow customization of the badge for specific applications. Thus, for example, the badge can serve as a paging device for displaying a short message upon receiving a remote communication and sounding the buzzer so as to alert the owner of an awaiting message.

Fig. 3 shows in greater detail the circuitry associated with the IR receiver 32 used in the badge 30. A similar circuit is likewise employed in the ceiling-mounted IR transceivers 21, 22 and 23 shown in Fig. 1. Thus, in both cases an IR photodiode array 41 is connected to a tuned resonant circuit comprising an tuned antenna coil 42 and a capacitor 43 for applying data to the gate of a MOSFET 44. The source of the MOSFET 44 is connected to the capacitor 43 via a resistor 45 and is fed via a coupling capacitor 46 to the IR transceiver 32 having therein a memory (not shown) for allowing data to be stored therein and to be extracted, or read, therefrom. The coupling capacitor 46 blocks the DC level but allows data to pass through to a low noise linear amplifier 47 operating at a basic frequency 455KHz and having an output coupled to a band pass filter 48 having a bandwidth of 32KHz. The resulting carrier signal is fed to the input of a logarithmic amplifier and Received Signal Strength Indicator (RSSI) 49 allowing the signal strength to be displayed in suitable form. The signal passed by the RSSI 49 includes both data and noise and it is obviously important to filter out the noise so that the IR receiver 32 does not receive false signals. Only those signals which are determined to be genuine data signals are demodulated so as to extract the data.

To this end there is coupled a noise subtract unit 50 an output of which is fed to a capacitor 51 operating as a noise integrator whose output is fed to a first input of a summing amplifier 52. A second input of the summing amplifier 52 is connected to a variable threshold generator 53 whose threshold may be set

by a variable resistor 54 external to the IR receiver 32. The output of the summing amplifier 52, corresponding to the sum of the average noise and the noise threshold, is fed to the inverting input of a comparator 55 whose non-inverting input is fed to the RSSI signal produced by the amplifier and detector 49. The output of the comparator 55 is fed to a "wake-up" signal generator 56 and to a deglitcher 57 which suppresses any pulse whose time duration is less than 25 μ s and thus constitutes spurious glitches rather than actual signal data. Thus, when a signal is detected at the output of the deglitcher 57, corresponding to an actual received signal, the corresponding data associated therewith is extracted and detected.

To this end, the RSSI signal is fed to a peak detector 60 which measures its peak value and feeds it to a first, summing input of a summing amplifier 61 having a second, subtracting input connected to a variable threshold generator 62 whose threshold may be set by a variable resistor 63 external to the IR receiver 32. The output of the summing amplifier 61, corresponding to the difference between the peak value of the RSSI signal and the threshold, is fed to the inverting input of a comparator 64 whose non-inverting input is fed to the RSSI signal produced by the amplifier and detector 49. The output of the comparator 64 is fed to a deglitcher 65 which suppresses any pulse whose time duration is less than 25 μ s and thus constitutes spurious glitches rather than actual data. The waveforms associated with the decoded data, the RSSI and the "wake-up" signals are shown in Figs. 8a, 8b and 8c of the drawings.

Fig. 4 shows the frame configuration associated with the communications protocol according to the invention allowing up to four readers to effect bi-directional communication with a corresponding badge simultaneously. In order to explain this feature in context, reference is again made to Fig. 1 wherein each of each of the readers 21 to 23 (constituting location transceivers) has associated therewith a respective location ID so that each location ID uniquely addresses the respective location in which the location transceiver is

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mounted For ease of explanation, the respective location IDs for each of the location transceivers 21, 22 and 23 will be denoted by the corresponding room number #11, #12 and #13. Each of the readers 21 to 23 periodically communicates its location ID to the badges in its area of reception so that the
5 location of each badge may be stored therein. In order to prevent the risk of data collisions between the location transceivers 21 to 23, the communications protocol employs a data frame configuration wherein four different data slots DS1, DS2, DS3 and DS4 are allocated one to each of four different readers. Thus, each of the location transceivers 21 to 23 can transmit data only in its
10 own data slot thus avoiding the risk of data collisions between two or more respective location transceivers in mutual line of sight with the same badge.

Each of the badges 25 and 26 receives an IR data string transmitted by the location transceiver 22 and, possibly, also by the location transceivers 21 and 23 if the adjoining door between adjacent rooms 11 and 12 or between 12
15 and 13 is open. However, because the distance between the location transceiver 21 in an adjacent room and the badge 25 is greater than that between the badge 25 and the location transceiver 22 in the same room 12 as the badge 25, the intensity of the data received from the adjoining location transceiver 21 will be reduced compared to that received by the correct location transceiver 22. This
20 difference in signal intensity may be used in order to reject a weak signal emanating from a location transceiver in an adjoining room and thus containing the location ID of an incorrect location.

When one of the badges 25 or 26 receives the location ID #12 associated with the location transceiver 22, it compares the received location ID
25 with the current location ID stored within its internal memory. If these are identical, this means that the ID associated with the location transceiver 22 corresponds to the current location ID within the memory of the badge and that consequently the badge has not moved since it was previously updated. In this case, unless the badges 25 or 26 need, for some reason, to transmit data other

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than their respective ID, their respective IR transceivers may remain silent. By such means, battery consumption may be reduced to an absolute minimum.

If, on the other hand, the location ID (#12) transmitted by the location transceiver 22 is different to that stored in the badge memory, this implies that
5 the badge transceiver was moved into the room 12 since it was previously read. In this case, the location ID (#12) associated with the current location, i.e. the room 12, is now stored in the badge memory and the cycle is repeated.

Thus, referring now to Fig. 4, there is shown a typical frame configuration for allowing two-way wireless IR time division multiple access
10 (TDMA) transmission between the reader and the badge. Each Reader Control Message (RCM) includes a header, a reader ID and a cellular slot ID so as to allow a particular reader to be addressed when required. The RCM further includes a badge ID in respect of four different badges which may be addressed at a corresponding one of four data slots in the frame so as to provide each
15 badge with a command whose encoded data is transmitted at the corresponding slot. Finally, each RCM includes a CRC checksum which allows the integrity of the data received by the badge to be checked.

Following each RCM, are the four data slots depicted DSM1, DSM2, DSM3, and DSM4, respectively, within each of which a Data Slot Message
20 (DSM) may be transmitted. Each DSM includes a header and a reader ID. The data slot may be used to transmit a long data message having between 16 to 64 bytes included within the DSM slot followed by a validation check and a CRC checksum byte. If, on the other hand, the data which is to be transmitted to a particular badge corresponds to a short data message, this is provided in the
25 form of an Allocation Slot Message (ASM) which is transmitted in one of sixteen slots following the fourth data slot (DSM4). Each ASM comprises a header and a message type followed by a short data message of up to 16 bytes. Thereafter follows the badge ID followed by a CRC.

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Thus, each data cycle commences with a synchronization signal after which start synchronization signals are allocated in respect of each of the four data slots relating to the corresponding rooms 11 to 14. The four data slots may be needed (according to the four-color map theorem) in order to avoid having two areas whose respective readers attempt to transmit during the same data slot and thus avoid data collisions. It will be appreciated that if the topography shown in Fig. 1 is extended to include additional rooms, then those additional rooms may likewise be allocated data slots within the same overall cycle without in any way conflicting with the three location transceivers 21 to 23 shown in Fig. 1. For example, if there were an additional room adjacent to the room 12 but remote from the room 13, then providing such a room were allocated a different data slot to the two rooms 12 and 13, there would be no danger of collision between the data transmitted by the respective location transceivers in each of the three adjacent rooms. For such a topography, it may be shown that a minimum of four discrete data slots is sufficient to prevent data collisions. It will be appreciated from the foregoing that the invention allows communication between several readers and badges within a single data stream.

The manner in which the data slots are allocated so as to avoid data collisions may be pre-determined either by a professional installation expert with a software interface and an exact map of the area 10; or, it may be determined automatically, on a trial-and-error basis, by the location transceivers themselves by means of listening to each other's transmissions and proceeding with the definition in a neural/serial manner.

If a message must be addressed to the badge, or received thereby, within the area covered by the specific location transceiver, each RCM may contain commands and corresponding IDs in respect of up to five different badges. The commands control the use of the rest of the frame which, as shown, is divided into four data slots. An additional time is allocated at the end of the frame for badge allocation slots.

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Collision avoidance between the different location transceivers is achieved as explained above by allocating discrete data slots so that adjacent location transceivers may transmit only in their own respective data slots. Collision of data transmitted by different badges within a given area is achieved as follows. The badges do not transmit asynchronously. Instead, the location transceiver transmits the RCM and this defines the start of each frame. In each frame there are four data slots and sixteen allocation slots. If there is a message to be transmitted from the location transceiver to the badge, then the RCM transmitted to the badge includes command data for instructing the badge to receive the message in an allocated data slot. Longer messages may use more than one slot per frame (if preferred) or, alternatively, more slots in multiple frames.

A badge which needs to transmit its ID to a location transceiver; randomly selects one of the sixteen allocation slots for transmitting its ID therein. Thus, the probability of collision is reduced by 1:16 and in following frames 1:16² etc. If the badge needs to transmit to the location transceiver a longer message including, for example, data other than the object's ID, then it initially transmits a message of type "allocation" and in the following frame it will then be instructed by the location transceiver to transmit its message in a specific data slot.

Fig. 5a shows respective data structures 70 and 71 for the reader and the badge during the nth frame as well as respective data structures 72 and 73 for the reader and the badge during a subsequent (n+1)th frame for data transmission of a long message from the reader to the badge. For the nth frame the reader transmits a RCM which is received by the badge to which it is addressed, whereby it is decoded and an acknowledgement is transmitted by the badge to the reader during a randomly allocated slot. During the next frame, the reader informs the addressed badge during which data slot message information will be transmitted. Thus, as shown in the data structures 72 and 73, message

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data for the addressed badge is transmitted in the third data slot DSM3. The addressed badge receives the data during this slot and transmits an acknowledge signal ACK back to the reader during a randomly allocated ASM.

Fig. 5b shows corresponding data structures 74 and 75 for the reader and the badge during the n th frame as well as respective data structures 76 and 77 for the reader and the badge during a subsequent $(n+1)^{\text{th}}$ frame for data transmission of a long message from the badge to the reader. Thus, as shown data structure 74, the RCM is transmitted from the reader to the badge and during the randomly allocated ASM, the badge transmits a request to the reader for Long Message Transmission. As shown by the data structure 76, the reader commands the badge at what DSM to transmit, e.g. DSM3. In this case also, correct data transmission is acknowledged by means of an ACK signal transmitted during a randomly allocated ASM.

Fig. 5c shows corresponding data structures 78 and 79 for the reader and the badge during the n frame and during a subsequent $(n+1)^{\text{th}}$ frame for data transmission of a short message transmission from the badge to the reader. Thus, upon receipt of an RCM by the badge, the badge transmits a short message during a randomly allocated ASM which is received by the reader and acknowledged during the subsequent RCM transmitted thereby.

Fig. 5d shows identical data structures 80 and 81 for the reader and the badge, during the n th frame and during a subsequent $(n+1)^{\text{th}}$ frame for short location messages sent by the badge to the reader, which is transmitted during one of the randomly allocated ASMs.

Figs. 6a shows the IR modulation scheme employing on-off keying (OOK) modulation of the 455KHz pulse train constituting the modulated carrier transmitted by the reader. A high logic level constituting logic "1" is thus represented by an absence of data whereas a low logic level (logic "0") results in a modulated pulse being transmitted by the reader to the badge.

Fig. 6b shows a Reader Control Message (RCM) transmitted by the reader to the badge comprising a 455KHz carrier preamble followed by a plurality of data words. A similar data slot message or allocation slot message is sent by the badge to the reader comprising a short preamble in the form of a
5 455KHz carrier signal followed by words of actual data.

Figs. 7a to 7e show various timing diagrams associated with the IR Receiver 32 within the badge 30. Thus, as shown in Fig. 7a, the IR Receiver 32 within the badge 30 is dormant until read by a "wake up" signal having a time duration of approximately 1 ms as shown in Fig. 71). Each data packet
10 transmitted by the reader to the badge comprises an initial preamble in the form of a 455KHz carrier signal having a time duration of approximately 2 ms. This wakes up the badge, whereupon as shown in Fig. 7c the power supply controller 39 becomes operative for supplying power to the IR Receiver 32 so that after a small time delay $T_{\text{data delay}}$ after the preamble, data transmitted by the
15 reader is received by the badge as shown in Fig. 7d.

As further shown in Fig. 7a which is merely a repeat of Fig. 6b described above shown alongside the other timing diagrams for ease of comparison, actual data is transmitted from the reader to the badge following the initial preamble. Consequently, this data will reach the badge only after the
20 badge has passed from its initial dormant state, when the battery is on standby and, as shown in Fig. 7e, the battery current is thus minimal, to its operational state, wherein battery current increases to its operational level.

Figs. 8a, 8b and 8c show timing diagrams of a data decoding circuit used in the IR receiver 32 of the Badge 30. In order to understand these
25 diagrams, reference is again made to Fig. 3 showing a detail of the IR receiver 32. The RSSI signal shown as 90 in Fig. 8a is taken from the output of a logarithmic amplifier thus accounting for its irregular shape. The average noise derived at the output of the noise integrator is shown in Fig. 8a as a noise floor 91, whilst an upper noise limit 92 is shown as a 13.5 dB offset from the noise

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floor 91. The 13.5 dB offset is set by the noise threshold generator 53 and the external potentiometer 54 shown in Fig. 3. That is to say, the upper noise limit 92 defines the largest signal which could conceivably be noise: anything larger is accepted as genuine data. The upper noise limit 92 thus defines the level of the "wake up" signal 93 shown in Fig. 8b. For so long as the RSSI signal 90 is greater than the noise threshold 92, the "wake up" signal 93 is HIGH, and the data signal derived from the peak detected RSSI signal is demodulated to produce the pulse train shown as 94 in Fig. 8c. The pulse train 94 is derived by clipping the RSSI signal 90 by 6dB, this being the peak threshold set by the threshold generator 62 and the external potentiometer 63 shown in Fig. 3 and shown as 95 in Fig. 8a. The threshold 95 is subtracted from the RSSI signal 90 by the summing amplifier 61 which operates as a subtractor.

Fig. 9a is a flow diagram showing the principal operating steps carried out by the reader during the transmission of a long message to the badge. At the start of this procedure, the reader obtains from a central computer message data destined for a specified badge. The reader prepares an RCM for the identified badge and transmits the RCM, whereafter it awaits acknowledgement from the specified badge during one of the ASM slots. Upon receipt of the ASM, the data is decoded and, if correct, the next RCM is prepared indicating that a command destined for the identified badge will be encoded at slot K. The appropriate DSM is prepared by the reader at slot K and transmitted therein to the badge. The reader then awaits acknowledgment from the badge during the allocated slot, upon receipt of which this cycle of communication is complete. It is to be noted that if the acknowledgment by the badge to the reader indicates faulty communication, then the appropriate loop is repeated up to three times, whereafter in the absence of good data transmission, the reader informs the central computer that communication with the specified badge has failed and the reader then resumes normal operation.

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Fig. 9b is a flow diagram showing the principal operating steps carried out by the badge during the transmission of long message data by the reader to the badge. Thus, initially, the badge is in standby mode until it receives an RCM from the reader. Upon receipt thereof, the RCM is decoded by the badge in order to establish the badge ID to whom the data is transmitted. If the badge ID corresponds to the ID of the receiving badge, then the receiving badge prepares an acknowledge signal ACK which is then transmitted during the randomly allocated ASM slot. The badge then awaits receipt of the next RCM having a destination ID which corresponds to its own ID. Upon receipt thereof, the RCM is decoded and establishes that data will be sent by the reader to the badge in slot K. The data is received at slot K of the DSM and is decoded. If the data is received intact, the badge executes whatever function is required and then prepares an acknowledge signal so as to indicate whether the required function were carried out successfully or not. The ACK signal is transmitted by the badge to the reader during a randomly allocated ASM slot and the badge returns to standby mode.

Fig. 10a is a flow diagram showing the principal operating steps carried out by the reader during the transmission of a long message from the badge to the reader. Thus, upon receipt of an ASM from the badge, the ASM is decoded and the parameters therein are stored. Thereafter, the next RCM is prepared and transmitted to the badge. The reader then awaits receipt of a DSM from the badge, upon receipt of which the data is decoded and, if intact, is stored and forwarded to the central computer. Thereafter, the next RCM is prepared acknowledging receipt of the DSM. The RCM is transmitted to the badge and receipt of the ASM transmitted by the badge is then awaited. Upon receipt of the ASM, the reader decodes the data, and, if intact, resumes normal operation.

Fig. 10b shows the corresponding flow chart relating to the principal operating steps carried out by the badge during the transmission of a long message to the reader. Initially, the ASM and DSM are prepared and the badge

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then awaits receipt of a RCM transmitted thereto by the reader. Upon receipt of the RCM, the data is decoded and, if intact, the parameters are stored. It will be recalled that the parameters correspond to the information transmitted by the reader to the badge indicating in which DSM subsequent data is to be transmitted by the badge to the reader. Receipt of the RCM is then acknowledged by the badge in the next ASM. The badge then awaits receipt of the next RCM, upon receipt of which the data is decoded and, if intact, this permits determination as to which data slot contains the transmitted data intended for the current badge. If no ID is found, the loop is repeated until a valid RCM is received. Again, in the absence of a valid RCM being received within a predetermined number of cycles (i.e. as shown in the figure) a communication error is provided and the badge returned to standby mode.

At this stage, assuming that data has been received intact and properly decoded, the badge is informed that it must transmit the data to the reader in DSM slot K. The required data is therefore decoded in slot K and transmitted by the badge to the reader, whereupon the badge now awaits receipt of a subsequent RCM from the reader. Upon receipt thereof the transmitted information is decoded and if the RCM is valid, the badge checks whether the receipt of the data previously sent by the badge to the reader has been acknowledged by the reader. If so, then a suitable signal may be output (e.g. an audible beep); the end ASM is prepared and transmitted; and the badge returns to standby mode. As before, in the absence of receipt by the badge of a suitable acknowledge signal within a predetermined number of cycles, a communications error is displayed and the badge resorts to standby mode.

Fig. 11a is a flow diagram showing the principal operating steps carried out by the reader when the badge sends a short-location message thereto. Thus, upon receipt by the reader of a badge ASM, the received data is decoded and, if valid, the short parameters are stored and the message corresponding thereto is transmitted to the central computer. Thereafter, the reader prepares the next

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RCM containing a suitable acknowledge signal which is then transmitted to the badge, whereupon the reader resumes normal operation.

Fig. 11b shows the corresponding flow diagram of the functions performed by the badge during transmission of a short location message to the reader. The ASM-short message is prepared whereafter the badge awaits the RCM from the reader which should be received within a predetermined time period $t < T$. if the RCM is received within the correct time period, it is decoded and, if valid, the parameters encoded therein are stored. The ASM-short message is then transmitted to the reader and the badge awaits the RCM transmitted by the reader. Upon receipt thereof the RCM is decoded and, if valid, the acknowledged message is decoded in order to verify that the short message transmitted by the badge to the reader was received correctly. In this case, no further action is required.

If on the other hand, the acknowledged signal is negative, the badge re-transmits the short message to the reader, the whole cycle being repeated for a predetermined number of cycles e.g. 3 whereafter, if still no acknowledged signal is correctly received, a communication error is displayed and the badge returns to standby mode. Likewise, if no RCM is received by the badge within the allotted time period T , there is again assumed to be a malfunction, whereupon a communication error is displayed and the badge resorts to standby mode. The assumption is that when a badge indicates to the reader that it wishes to transmit a short message thereto, the reader will acknowledge that request substantially immediately unless, of course, communication between the reader and the badge is broken for some reason. Therefore, lack of receipt by the badge of the RCM within this time period is interpreted as a fault in the communication between the reader and the badge.

Although the communication protocol has been described with particular reference to a single communication between the reader and a badge, it will be understood that since four DSM slots are allocated simultaneously by

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the reader, each badge receiving data destined therefore in only one of those four slots, there may be enacted four different communications simultaneously. This is done without effecting a corresponding increase of the RCM time because the RCM header data is constant for all four data slots and allows each
5 of four different badges to determine in which slot data has been transmitted. This, in turn, means that each badge need only decode the data in the corresponding data slot, verify and acknowledge and this means that the data may be received by four different badges virtually simultaneously with minimum communications overhead.

10 It will further be appreciated that whilst the communications protocol has been described with particular reference to its implementation in a portable ID badge for maintaining track of a moveable object or person, it may equally well be employed in other applications and is clearly not restricted to such a system.

15 In the method claims that follow, alphabetic characters used to designate claim steps are provided for convenience only and do not imply any particular order of performing the steps.

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CLAIMS:

1. A method for effecting bi-directional IR data communication between a plurality N of readers (21, 22, 23) and a plurality M of portable objects each having associated therewith a respective object transceiver (24, 25, 26, 27) which is initially dormant and has embedded therein a respective object ID uniquely identifying the object, the method comprising the steps of:

each reader transmitting to an object transceiver a preamble containing a carrier signal for awaking the object transceiver from its initially dormant state,

each reader transmitting a Reader Control Message (RCM) including a header; a respective reader ID so as to allow the reader to be addressed when required followed by up to K object IDs ($K < M$) each in respect of one of said object transceivers and each being followed by a respective command for controlling the respective object transceiver,

allocating up to K data slots each for allowing communication of a data message between the respective reader one of said object transceivers, and

allowing each of the M object transceivers to randomly select of one of R allocation slots for transmitting limited capacity data therein to the respective reader.

2. The method according to Claim 1, wherein the data message includes a header and a reader ID of the respective reader followed by long message data having up to a predetermined number of bytes for transmission within the data slot.

3. The method according to Claim 1 or 2, wherein said limited capacity data comprises a header and a message type followed by a short message of up to a predetermined number of bytes data.

4. The method according to Claim 1 or 2, wherein said limited capacity data is an acknowledge signal.

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5. The method according to any one of Claims 1 to 4 for keeping track of up to M objects each having a respective unique identity and subject to movement between different locations, wherein:

- 5 (a) in each different location there is provided a respective one of said readers (21, 22, 23) each having associated therewith a location ID uniquely identifying the respective location,
 - (b) with each of the objects there is associated a respective one of the object transceiver (24, 25, 26, 27) having embedded therein a respective object ID uniquely identifying the object,
 - 10 (c) each of said location transceivers periodically transmits its location ID for receipt by any object transceiver within a boundary associated with said location,
 - (d) any object transceiver receiving the location ID of a proximate reader; compares said location ID with a current location ID stored
15 in the object transceiver corresponding to the object's current location,
 - (e) if the location ID received in (d) is not the same as the current location ID in the object transceiver; the object transceiver randomly selects one of said R allocation slot for transmitting its
20 respective object ID to the reader associated with its current location and stores the respective location ID of said reader, and
 - (f) the reader stores the respective object ID of each object associated therewith.
6. The method according to Claim 5, further including the step of:
- 25 (g) all of the readers transmitting the respective object IDs of all objects associated therewith to a central tracking receiver (28) for maintaining a record of all location IDs and associated object IDs.

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7. The method according to Claim 5 to 6, wherein a signal transmitted by a reader is able to travel beyond the boundary associated with the reader and step (d) includes the further step of:

5 (dl) allocating to potentially conflicting readers discrete data slots for transmitting their respective location IDs so that no more than one location ID can be received at any given time by an object transceiver.

8. The method according to Claim 7, wherein each of the locations is a room, the boundary is a wall separating the room from an adjacent room and four discrete data slots are allocated each in respect of one of up to four adjacent rooms so that the respective reader in each of the adjacent rooms
10 transmits during its data slot only.

9. The method according to any one of Claims 5 to 8, wherein if the location ID received by an object transceiver is the same as the current location ID stored therein, the object transceiver maintains silence so as to minimize
15 energy consumption.

10. The method according to any one of Claims 1 to 9, wherein the object transceivers are adapted to transmit an object data stream containing the respective object ID and an additional message, there being further included the step of:

20 each of the object transceivers randomly selecting additional object transceiver data slots, as required, to completely transmit said object data stream.

11. The method according to any one of the preceding Claims, wherein the object transceivers and readers are IR transceivers.

25 12. An object transceiver (24, 25, 26, 27) which is programmed to carry out the method according to any one of Claims 1 to 11.

13. A reader (21, 22, 23) which is programmed to carry out the method according to any one of Claims 1 to 11.

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14. A system (10) comprising at least one reader (21, 22, 23) and at least one object transceiver (24, 25, 26, 27) which are programmed to carry out the method according to any one of Claims 1 to 11.

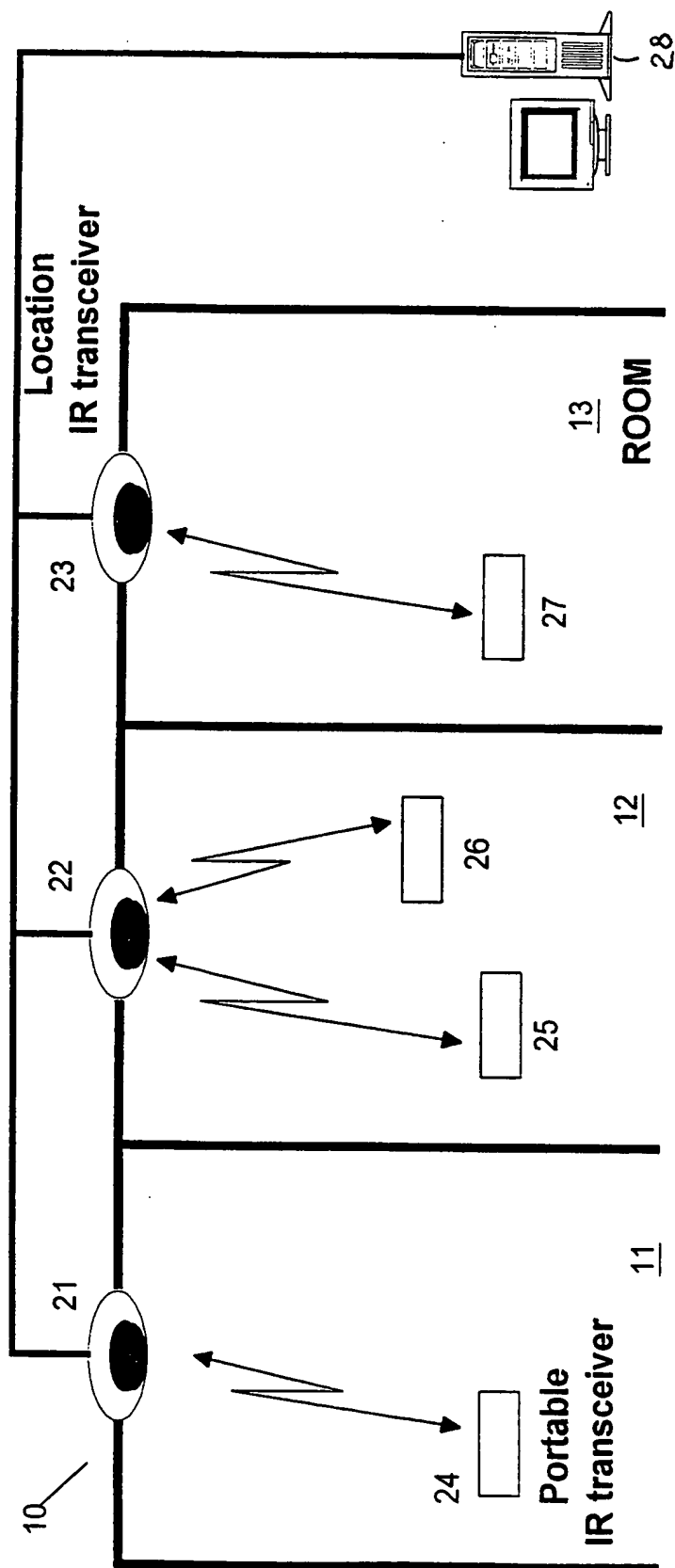


Fig. 1: Portable IR transceivers and Location IR transceivers

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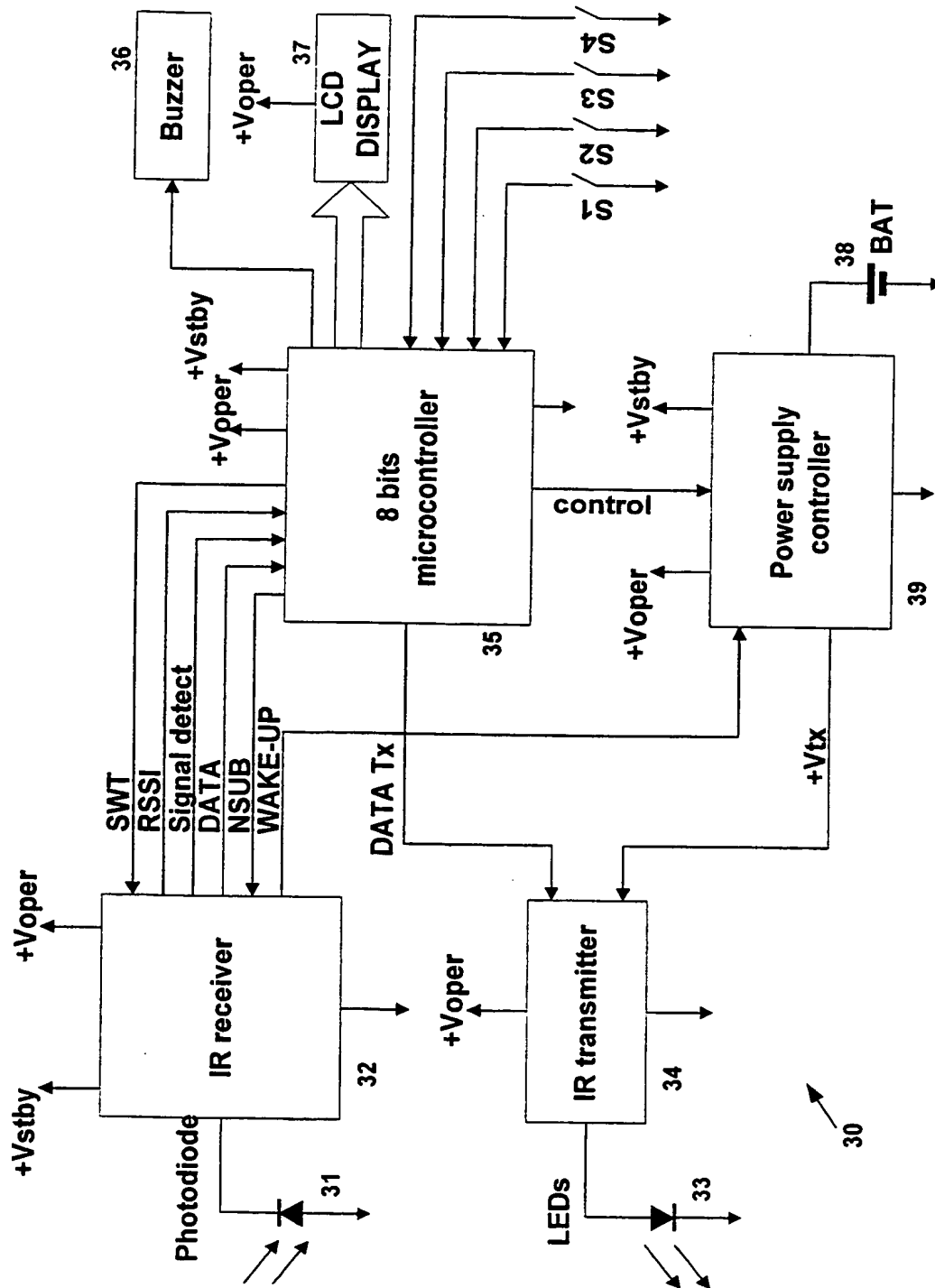


Fig. 2 : IR two way Portable Badge - Block Diagram

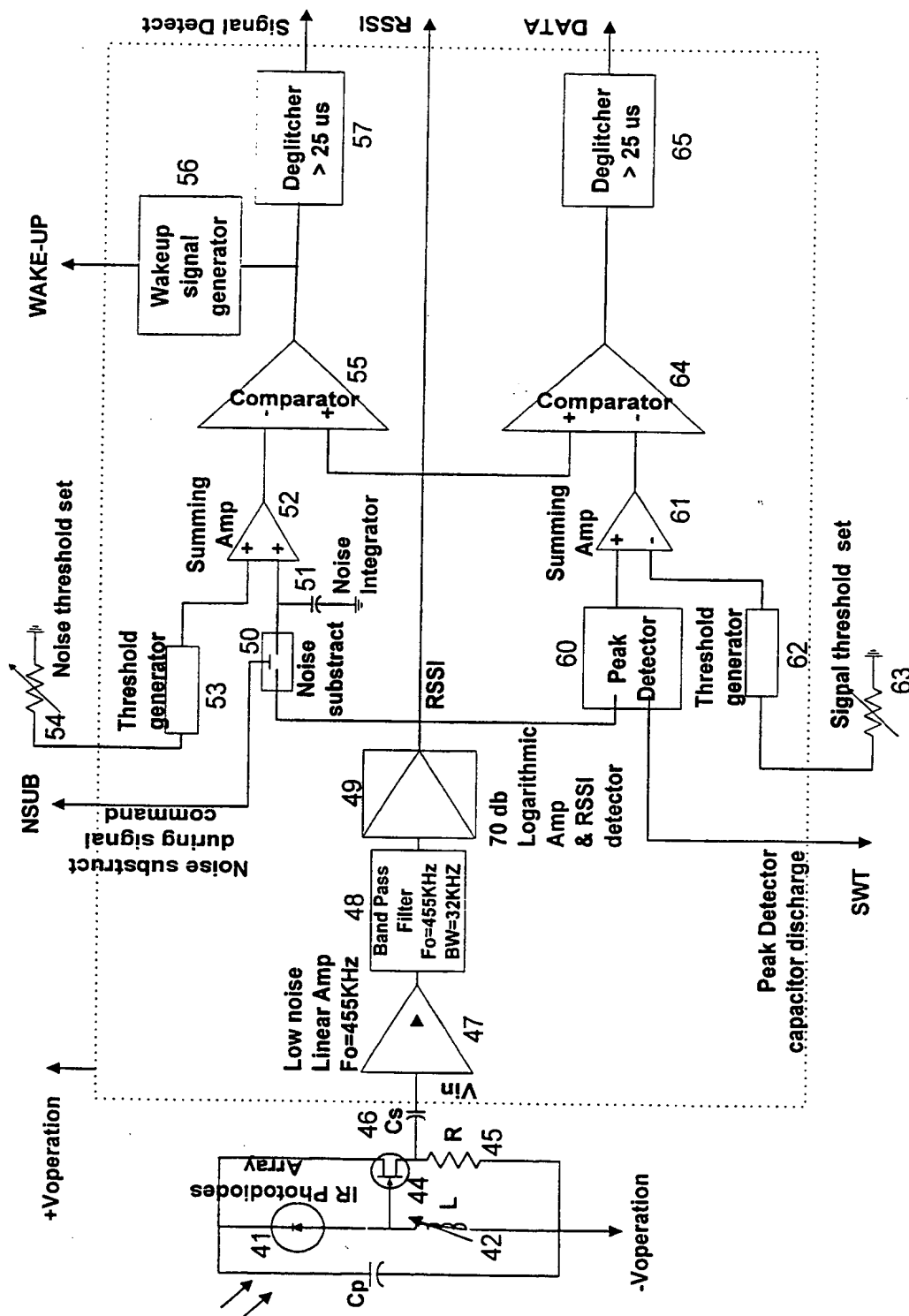


Fig. 3: Block diagram of IR receiver

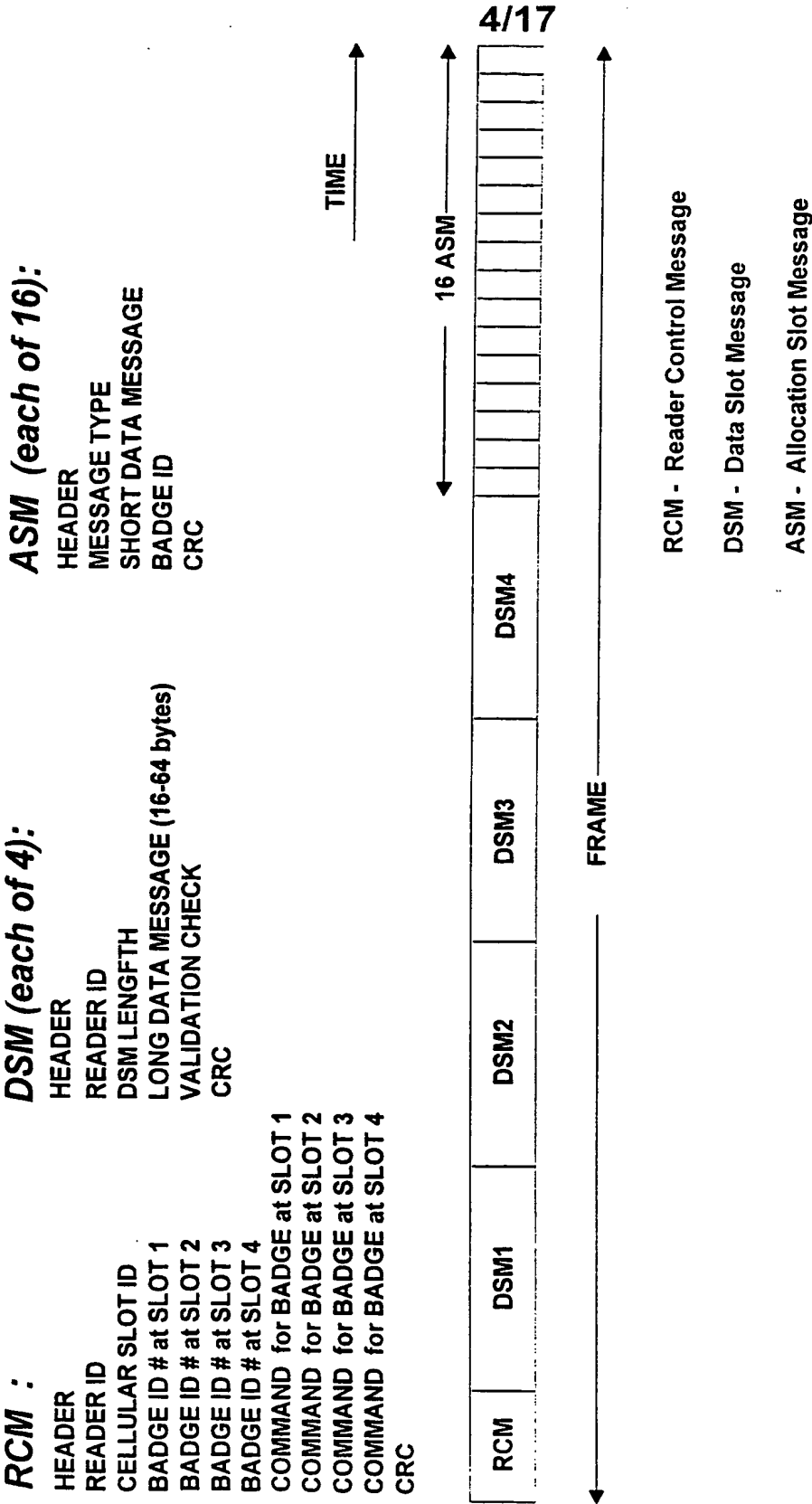


Fig 4: Two - Way Wireless IR TDMA Reserved ALOHA Protocol - Frame Configuration

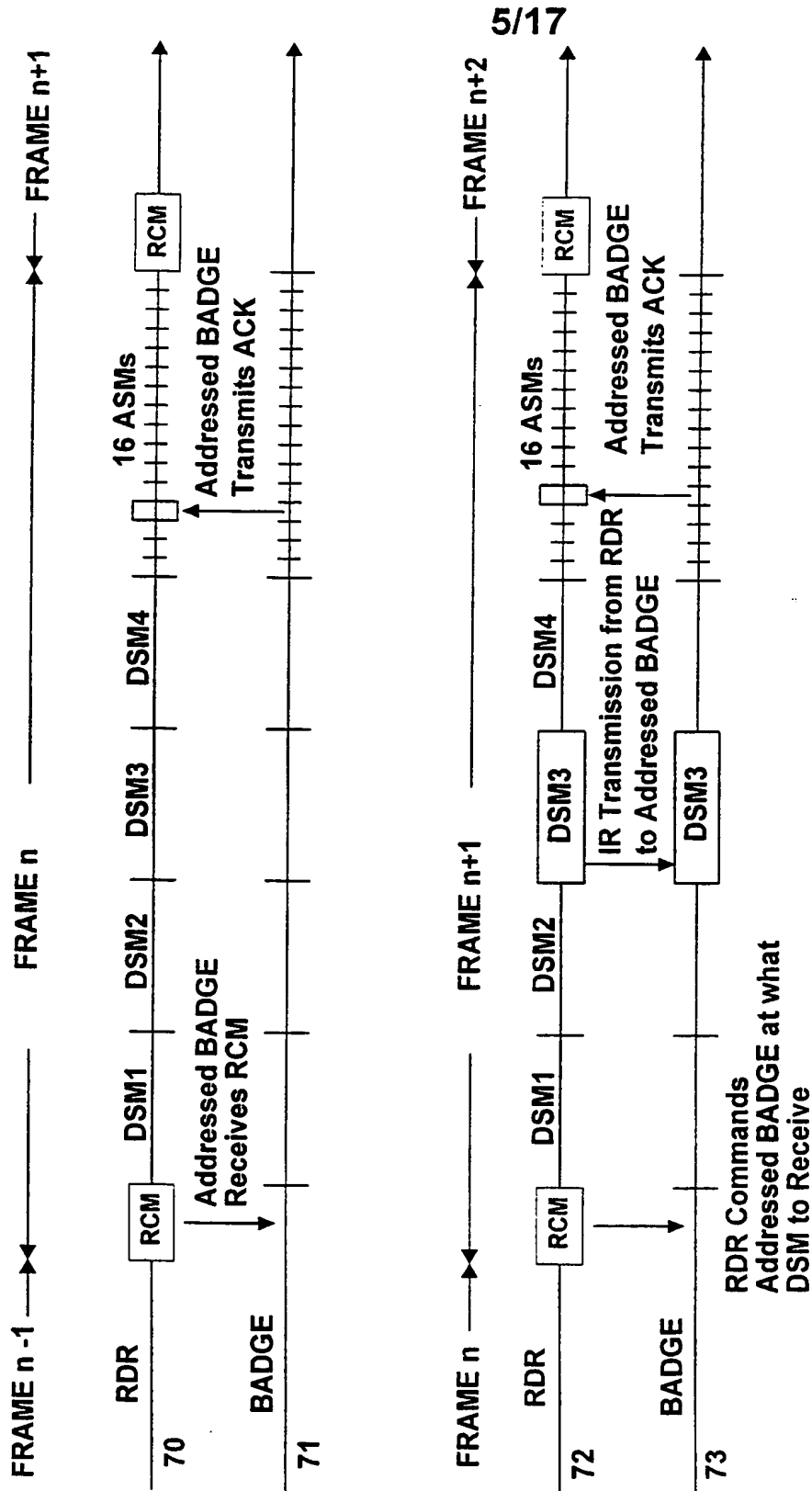


Fig 5a: RDR to BADGE Long Message Transmission Protocol

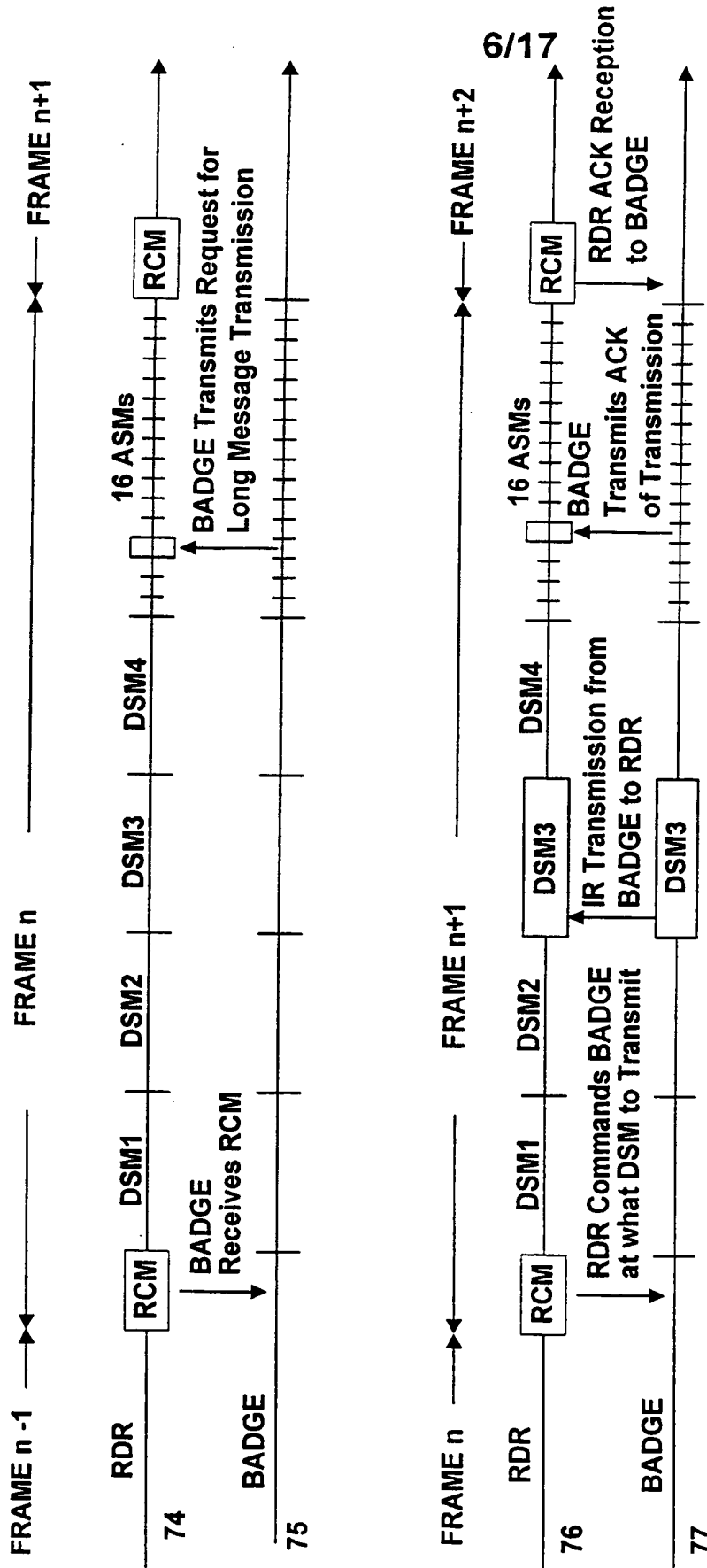


Fig 5b: BADGE to RDR Long Message Transmission Protocol

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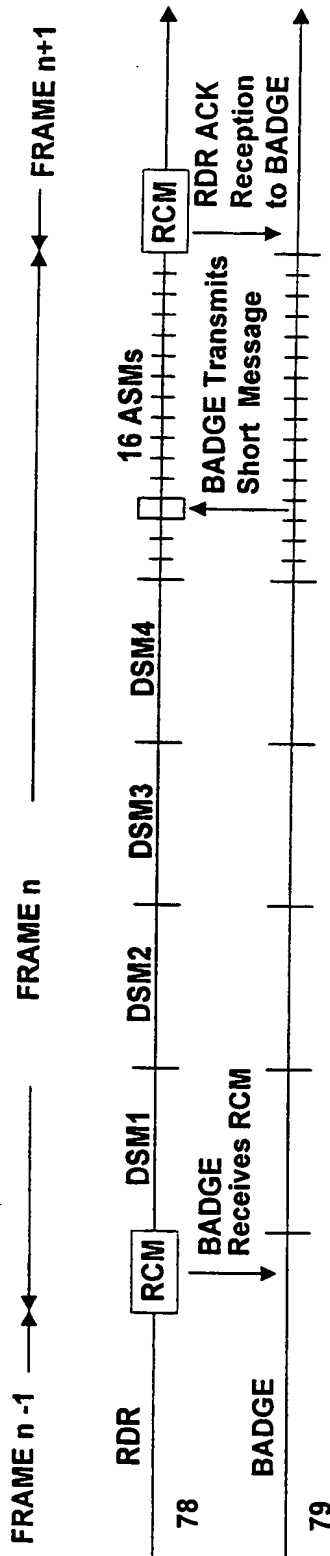


Fig 5c: BADGE to RDR Short Message Transmission Protocol

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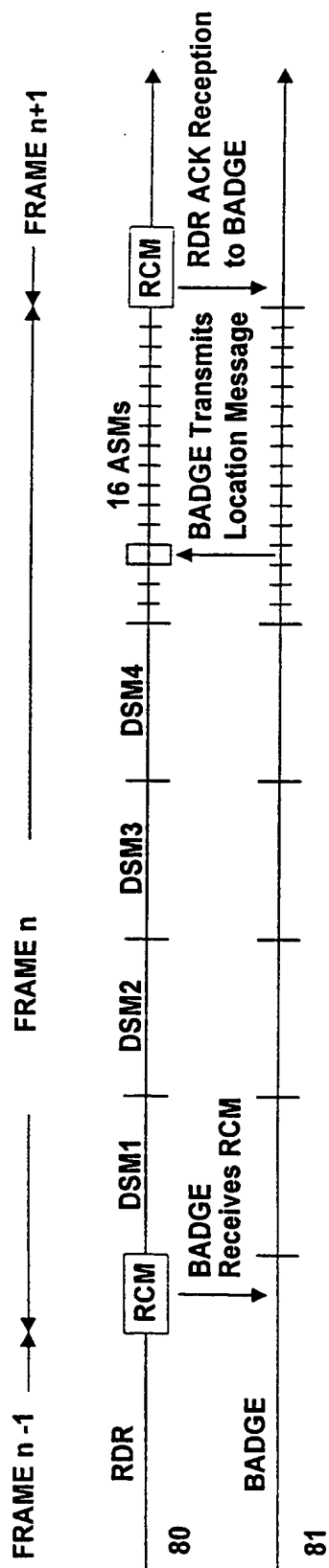


Fig 5d: BADGE to RDR Location Message Transmission Protocol

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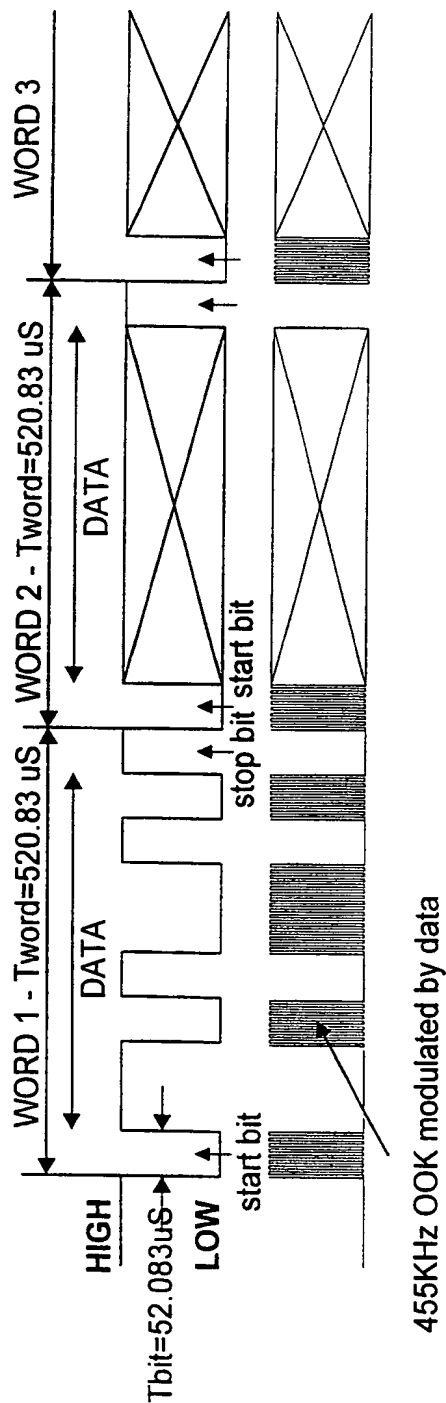


Fig 6a : IR Modulation Scheme (ASK OOK)

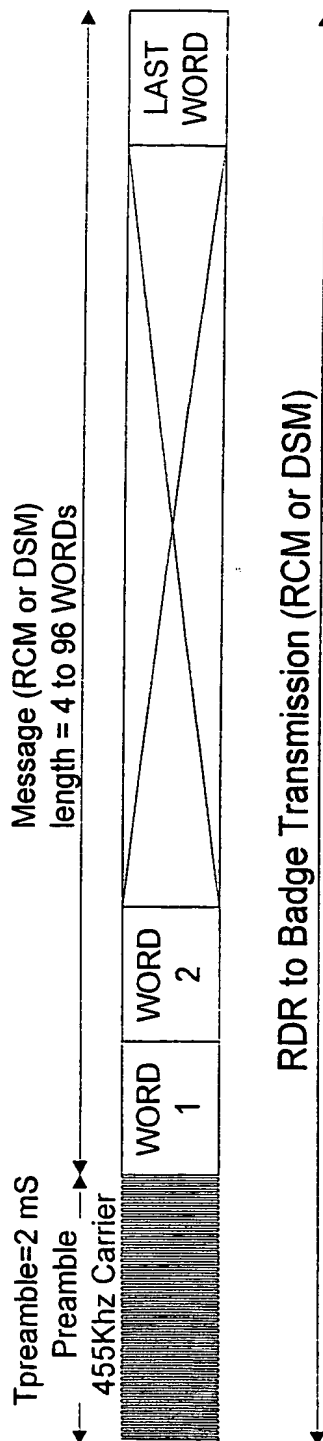


Fig 6b: RDR IR Transmission Protocol

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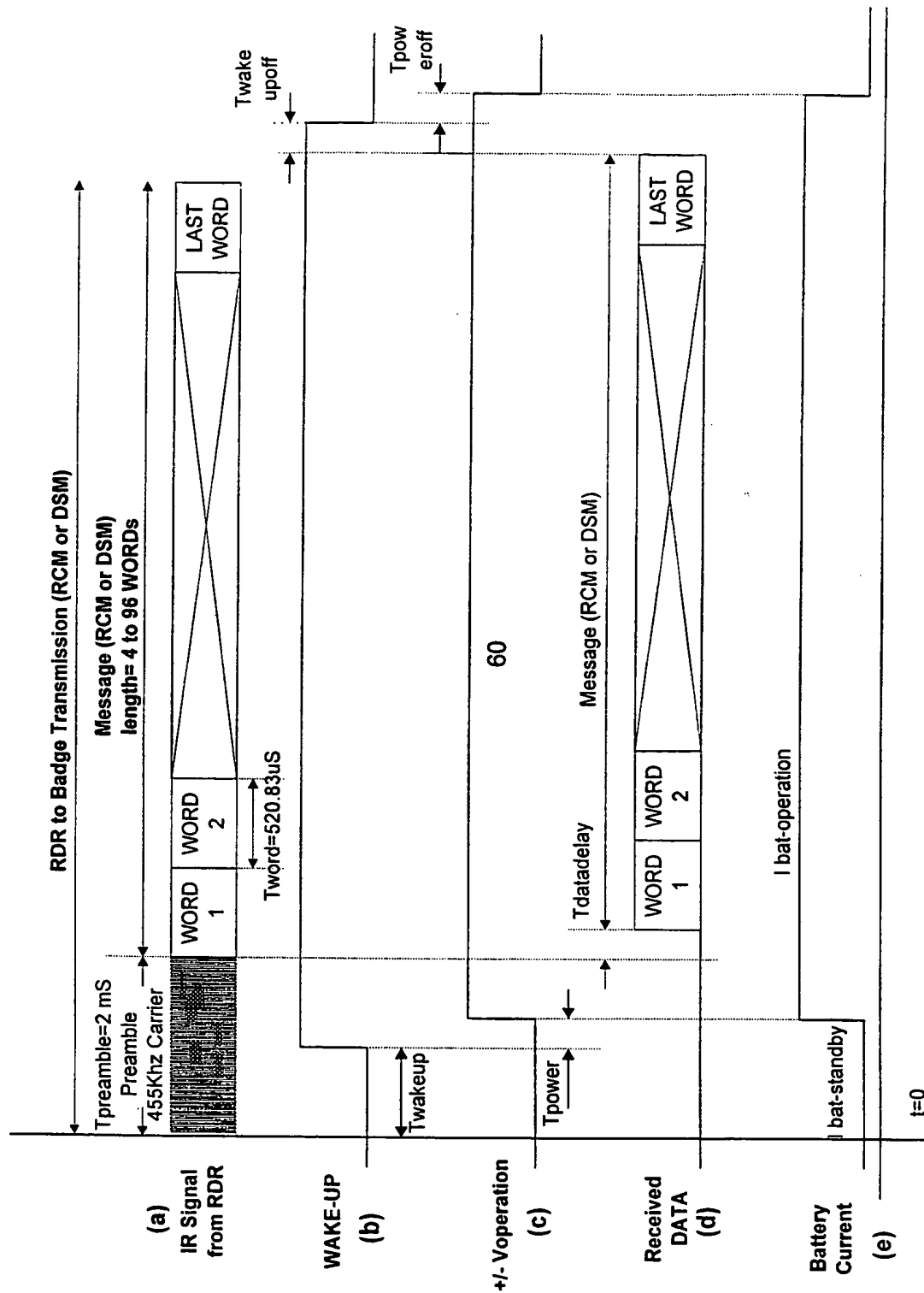


Fig 7: Timing Diagram of BADGE IR Receiver Operation

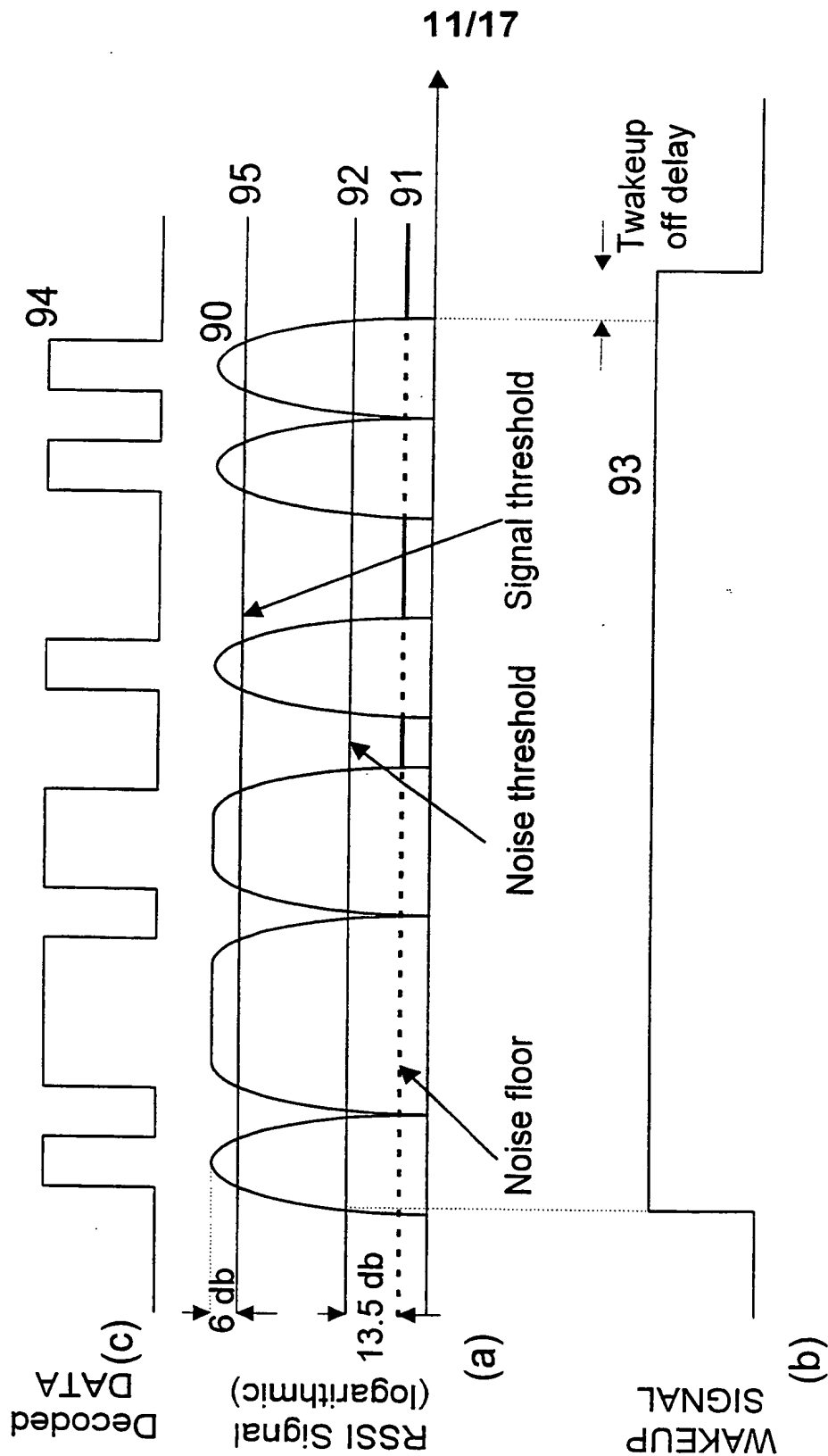
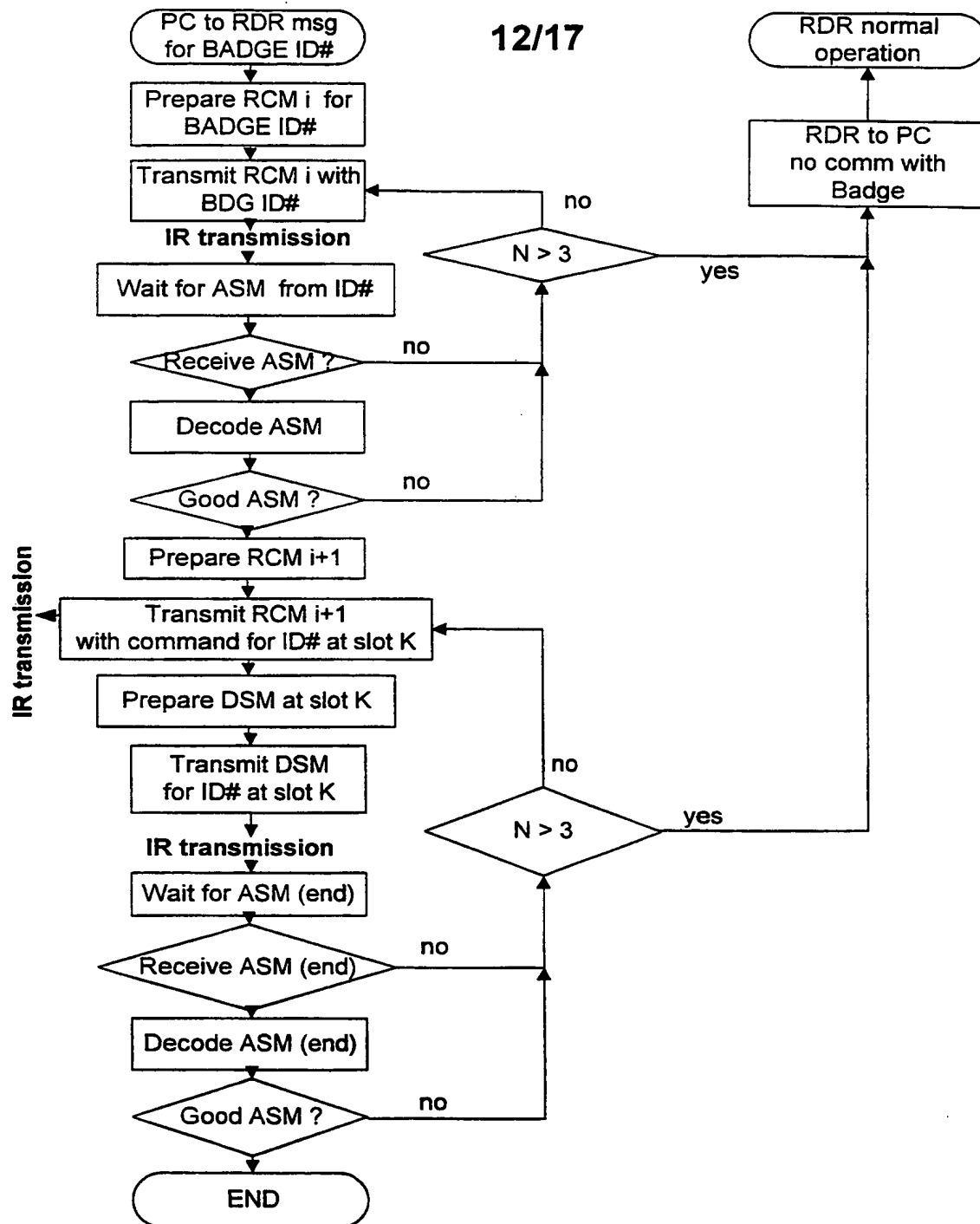


Fig 8: Timing Diagram of the DATA Decoding Circuit



**Fig 9a: RDR to BADGE Long Message Transmission Protocol
RDR Flow Chart**

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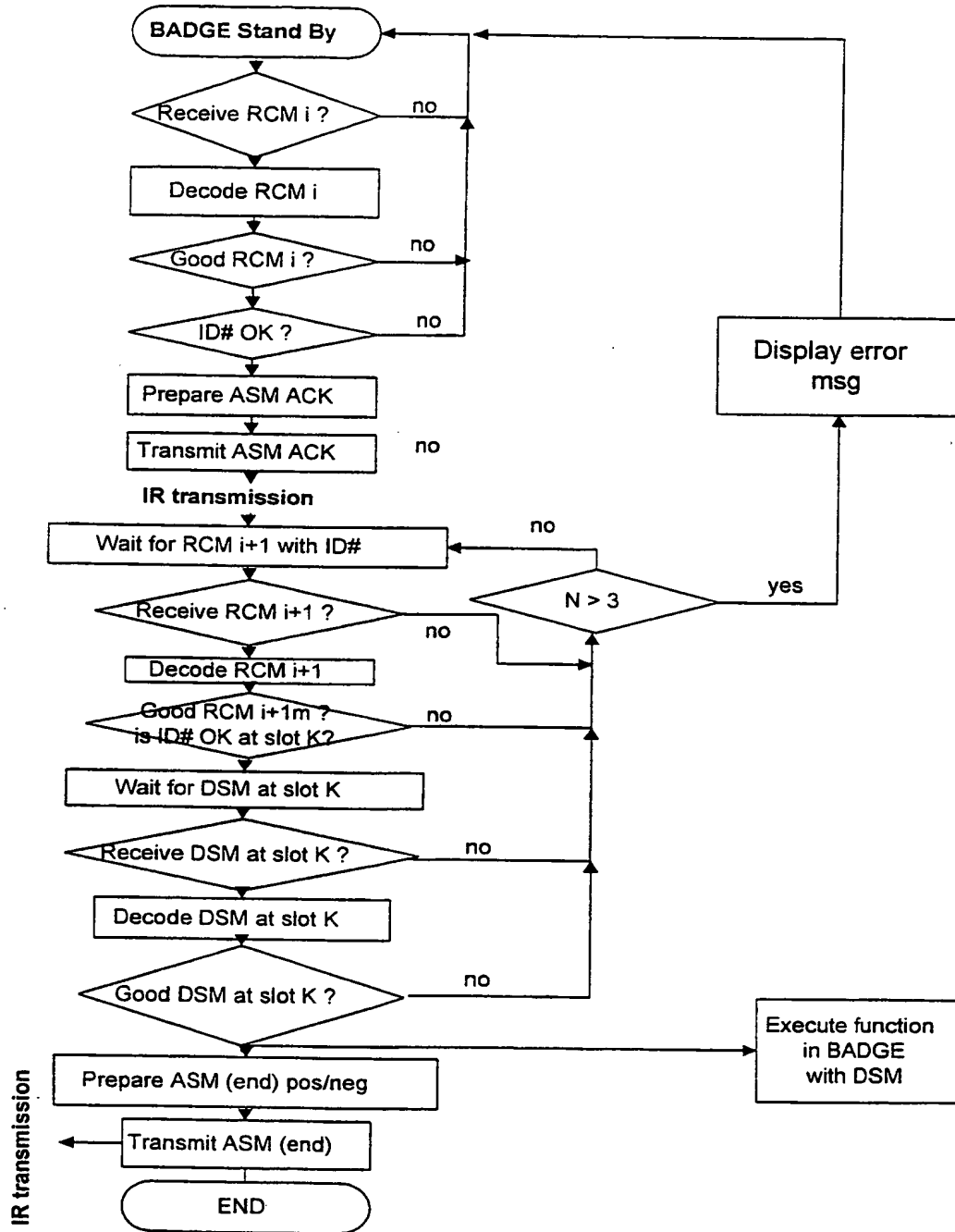


Fig 9b: RDR to BADGE Long Message Transmission Protocol
BADGE Flow Chart

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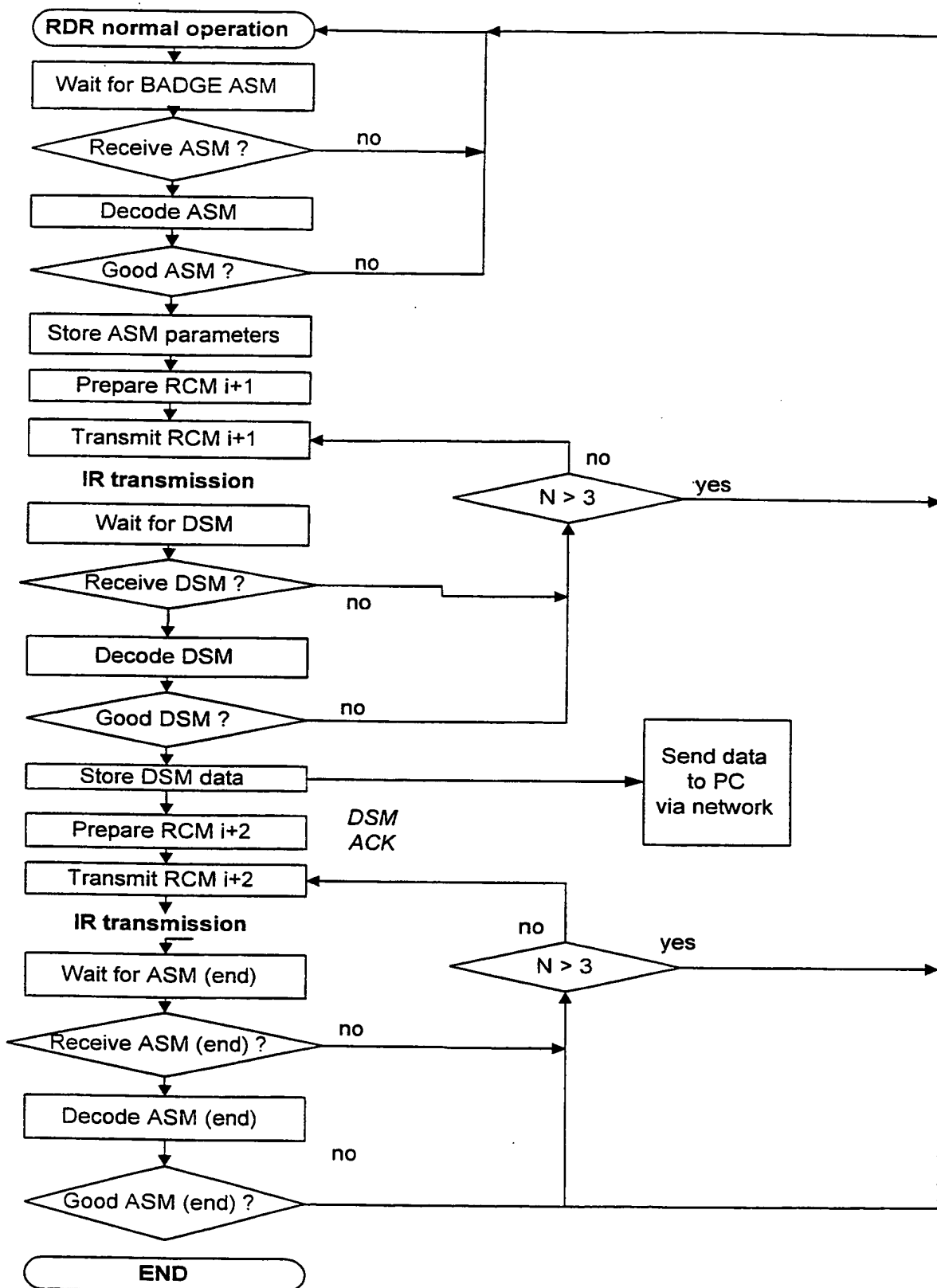


Fig 10a: Badge to RDR Long Message Transmission Protocol
RDR Flow Chart

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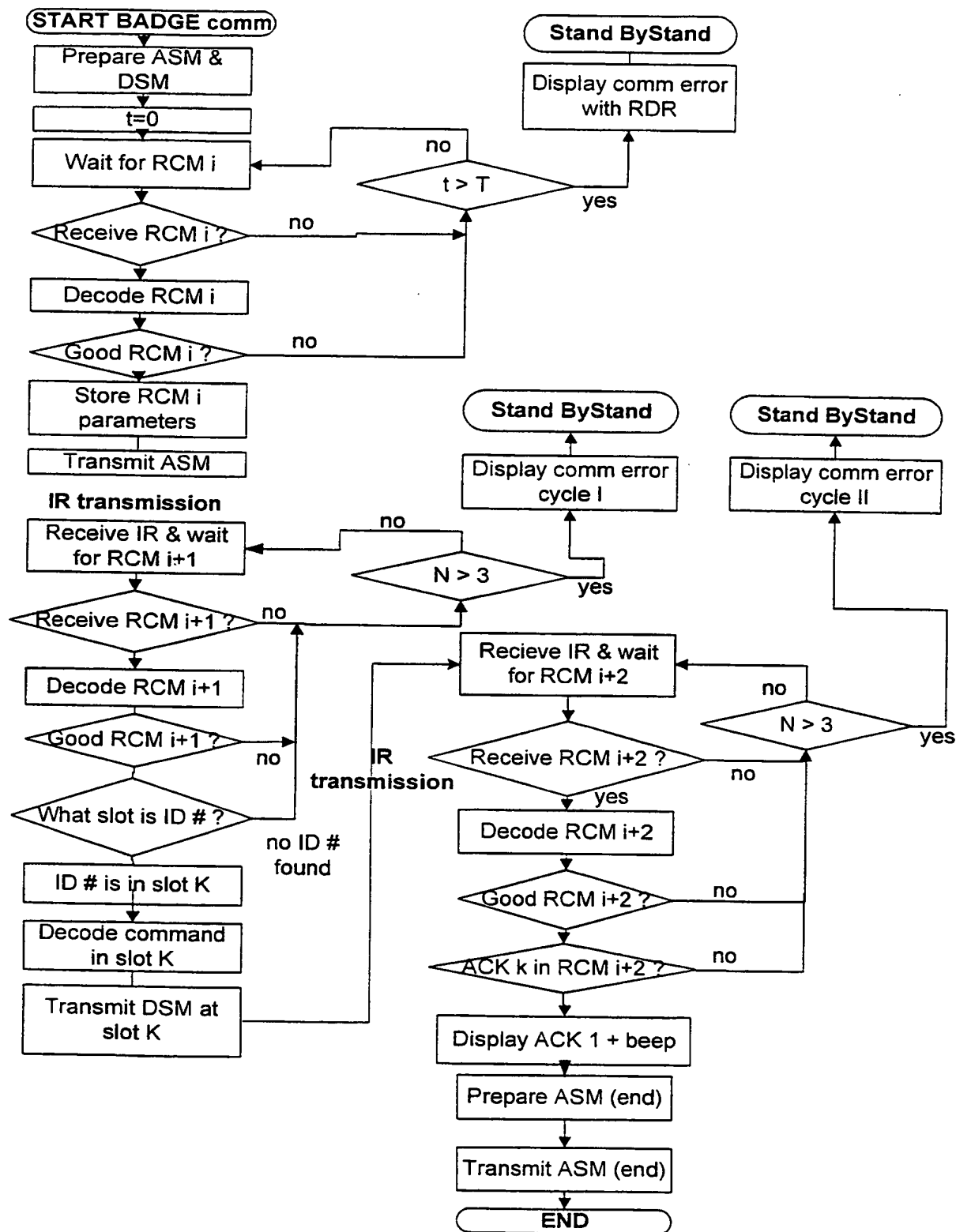


Fig 10b: Badge to RDR Long Message Transmission Protocol
BADGE Flow Chart

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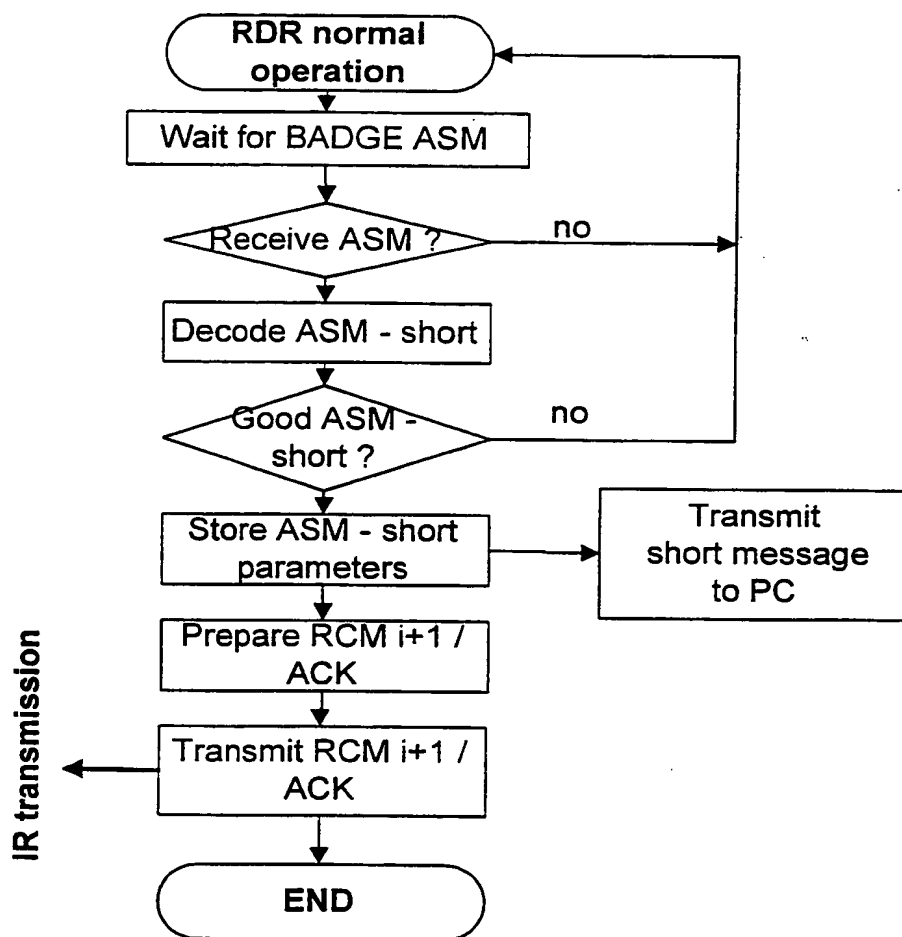


Fig 11a: Badge to RDR Short / Location Message Transmission Protocol
RDR Flow Chart

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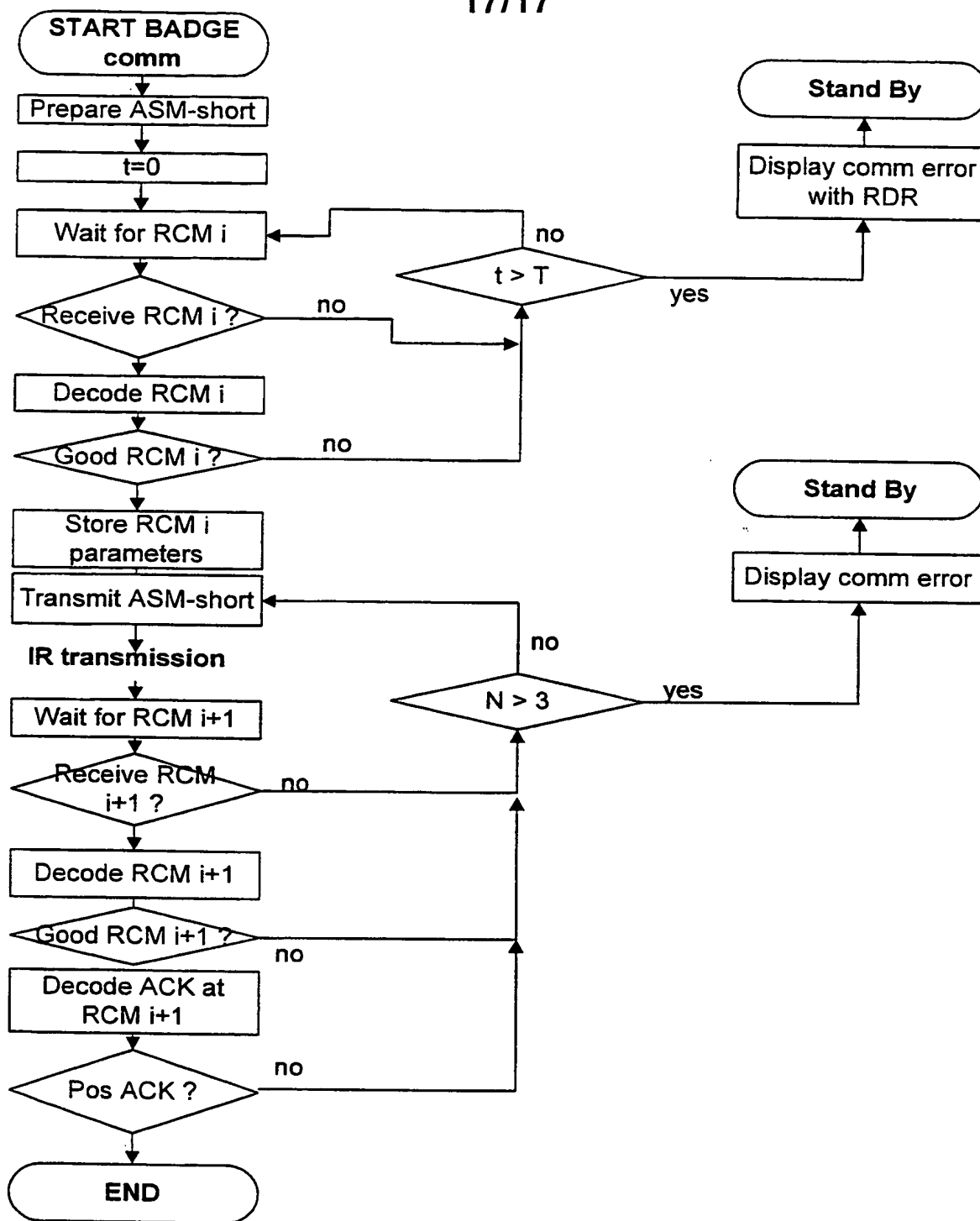


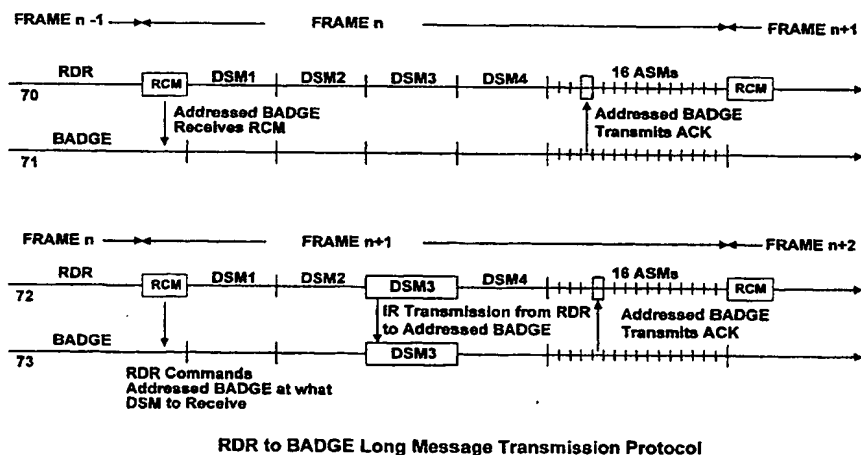
Fig 11b: Badge to RDR Short / Location Message Transmission Protocol
BADGE Flow Chart



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RDR to BADGE Long Message Transmission Protocol

(57) Abstract

A method and system for effecting bi-directional IR data communication between a plurality N of readers (21, 22, 23) and a plurality M of portable objects each having associated therewith a respective object transceiver (24, 25, 26, 27) which is initially dormant and has embedded therein a respective object ID uniquely identifying the object. Each reader transmits to an object transceiver a preamble containing the object ID for awaking the object transceiver from its initially dormant state, and a Reader Control Message (RCM) including a header; a respective reader ID so as to allow the reader to be addressed when required followed by up to K object IDs ($K < M$) each in respect of one of the object transceivers and each being followed by a respective command for controlling the respective object transceiver. Up to K data slots are allocated each for allowing communication of a data message between the respective reader and one of the object transceivers, and each of the M object transceivers may randomly select of one of R allocation slots for transmitting limited capacity data therein to the respective reader.

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Minimum documentation searched (classification system followed by classification symbols)

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Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

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A	<p>US 5 742 238 A (FOX CHRISTOPHER WAYNE) 21 April 1998 (1998-04-21) abstract column 1, line 9 - line 13 column 2, line 20 - line 28 column 3, line 37 - line 67 column 7, line 22 - line 28 column 7, line 35 - line 49</p> <p style="text-align: center;">--- -/-</p>	1-14

☒ Further documents are listed in the continuation of box C.

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Date of the actual completion of the international search

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INTERNATIONAL SEARCH REPORT

Int. Application No

PCT/IL 99/00572

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	<p>MARTIN B W: "WITCHIT. A FULLY SUPERVISED IDENTIFICATION, LOCATION AND TRACKING SYSTEM"</p> <p>PROCEEDINGS OF THE ANNUAL INTERNATIONAL CARNAHAN CONFERENCE ON SECURITY TECHNOLOGY, US, NEW YORK, IEEE, vol. CONF. 29, 1995, pages 306-310, XP000585871 ISBN: 0-7803-2628-8</p> <p>abstract</p> <p>page 308, left-hand column, line 1 - line 22</p> <p>page 309, left-hand column, line 1 - right-hand column, line 8</p>	1-14

Information on patent family members

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